DEPARTMENT OF VETERANS AFFAIRS

REHABILITATION RESEARCH AND DEVELOPMENT

NATIONAL CENTER FOR REHABILITATIVE AUDITORY RESEARCH

VA MEDICAL CENTER, PORTLAND, OREGON

ANNUAL REPORT

JANUARY 1, 2006 – DECEMBER 31, 2006

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I. BACKGROUND

Vision

Our vision is to be the national leader in rehabilitative auditory research and development, and a national resource for veterans, their families, their health care professionals, and the community at large.

Mission

The mission of the National Center for Rehabilitative Auditory Research is to benefit veterans by alleviating the communicative, social and economic problems resulting from auditory system impairments.

Relevance to Veteran Population

Auditory disabilities affect veterans of all ages and represented the most prevalent individual service-connected disability among veterans receiving compensation benefits from the Veterans Benefits Administration in fiscal year 2005 (VBA, 2005). More than 753,000 veterans were identified as having service-connected auditory disabilities that required compensation from the VBA. In FY 2005, total compensation to veterans exceeded $1 billion for hearing loss and tinnitus disabilities, an increase of 168% over the preceding four years. Furthermore, an estimated 1.5 million additional veterans are service-connected for their hearing loss and tinnitus, but do not receive compensation. In FY 2005, the VA dispensed 315,240 hearing aids, which, along with batteries and repairs, as well as audiologic services, cost $249 million. Most importantly for our veteran population, hearing loss and tinnitus can have a life-long negative impact on communication and quality of life.

VA research, while targeting veterans, provides significant benefit to all Americans. The VA's support of auditory rehabilitation research is equally important for veterans receiving compensation, for the millions of veterans who have a non-compensable hearing loss, and for the nearly 35 million individuals in the United States who are affected by hearing loss. This communication disorder—the most common chronic health condition in all age groups—profoundly affects social, vocational, and psychological functions (Ruben, 2000). The communication difficulties caused by auditory disabilities interfere with treatment of patients who have hearing impairment, as well as with the delivery of effective health care in general. Moreover, the incidence of hearing loss increases dramatically with age: about 40-45% of people over age 65 years have some degree of hearing loss, with the number increasing to about 83% in individuals over 70 years of age (Cruickshanks et al., 1998). In the 30 years between 1990 and 2020, it is projected that the number of veterans over 85 years will have increased by 568%; while the median age of veterans is projected to increase from about 58 years today, to over 62 years by 2020. As the population ages, the high incidence of hearing disabilities among veterans and the general population will create unprecedented demands for hearing healthcare services within the Department of Veterans Affairs (VA) and the private health care industry.

Unique Role of the NCRAR

The NCRAR was established in 1997, and is currently one of fourteen Centers of Excellence (COE) funded by the VA Rehabilitation Research and Development (RR&D) Service. It is the only such center dedicated to the discovery and delivery of cutting-edge solutions to auditory dysfunction. The NCRAR is also unique among auditory research facilities because of its focus on the rehabilitation of auditory dysfunction and translation of research findings into audiology clinical practice. The Center uses a multi-disciplinary approach that

includes both basic and clinical research components to bring diverse perspectives and solutions to common auditory problems. Our research strategy encompasses the progression from basic theoretical research to clinical care, including three major research areas: the *diagnosis and assessment* of auditory dysfunction, the development of *rehabilitation* approaches and techniques, and the *prevention* of hearing loss. We carry out clinical trials, develop technologies, and play an important role in cultivating the next generation of auditory researchers through education and mentoring programs. Furthermore, we serve as a resource for rehabilitative auditory research through the dissemination of research findings and patient information to rehabilitation professionals throughout the nation, ultimately benefiting veterans whose quality of life is diminished by hearing impairment. Core funding of the Center has been effective in developing one of the country's premier centers for auditory research, and has facilitated the acquisition of investigator-initiated research funds from diverse sources. The NCRAR is a VA research facility, staffed by VA researchers, carrying out rehabilitation research and development projects of high priority to the hearing health care of veterans.

The NCRAR contributes uniquely to the VA RR&D COE portfolio. Our goals include continuing existing lines of research while incorporating research initiatives of priority importance to current and future generations of veterans. COE funding allows the Center to advance these research, education, and training initiatives with a highly productive team of core investigators and associated scientists throughout the country and internationally.

II. SUMMARY OF PROGRESS FOR CALENDAR YEAR 2006

Stated Goals and Objectives

Consistent with the NCRAR's *Vision*, *Mission* and five-year strategic plan, our focus has been on: 1) improving the lives of hearing-impaired veterans and their families by advancing the discovery of new knowledge and technologies that optimize auditory rehabilitation, developing and rigorously evaluating useful innovations in the laboratory, and applying rehabilitation research solutions to clinical practice; 2) educating and influencing the rehabilitation community by disseminating evidence-based research findings and developing best practice procedures; 3) broadening its base of consenting research participants for clinical trials of new devices, techniques, programs, and outcomes measures; 4) expanding core, shared equipment and facilities resources, and support services; 5) cultivating and encouraging innovation and synergy of intellectual resources among multidisciplinary clinicians, public health specialists, research investigators, rehabilitation engineers, educators and administrators; and 6) supporting core researchers and key collaborators whose programs and projects are in turn, supported from a variety of federal, public and private sources to effectively leverage the center's core funding. Specific goals and objectives included:

- Become involved in training programs for the next generation of clinical audiologists and auditory research scientists.
- Compete successfully for continuation funding of the RR&D NCRAR.
- Continue to build capacity through recruitment and mentoring of pre- and post-doctoral fellows, mid- and junior-level clinical research-scientists, scholars and rehabilitation engineers who are deemed appropriate candidates for Associate Investigator, Research Career Development, Research Career Scientist, and other VA and non-VA research career development program opportunities.
- Complete the conceptualization, design, installation and performance verification of a fully-anechoic (echo-free) sound chamber.

- Conversion of the NCRAR's worldwide website (www.ncrar.org) to a "va.gov" web domain.
- Explore research collaborations in the area of vestibular dysfunction/balance disorders.
- Fulfill and expand rehabilitation research and development collaborations with:
  - Advanced Cochlear Systems, Snoqualmie, WA
  - DoD, Madigan Army Hospital, Fort Lewis, WA
  - DoD, U.S. Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, MD
  - DoD, U.S. Army Garrison, Fort Bragg, NC
  - Hearing Components, Oakdale, MN
  - NeuroTone, Inc., Redwood City, CA
  - OHSU, Oregon Graduate Institute, School of Science & Engineering, Departments of Biomedical Engineering and Computer Science & Engineering, Portland, OR
  - Polytrauma and Blast-Related Injuries Quality Enhancement Research Initiative (QUERI), Rehabilitation Centers, Minneapolis, MN and Palo Alto, CA
  - RR&D Center of Excellence on Restoration of Function in Spinal Cord Injury and Multiple Sclerosis, West Haven, CT
  - Sensimetrics Corporation, Somerville, MA
  - Southern Illinois University, School of Medicine, Division of Otolaryngology, Springfield, IL
  - The Smith-Kettlewell Eye Research Institute, San Francisco, CA
  - University of Auckland, School of Population Health, Section of Audiology, Auckland, New Zealand
  - University of California, San Francisco, School of Medicine, Division of Otolaryngology, Department of Audiology, San Francisco, CA
- Hearing loss prevention and hearing conservation programs and practices will be developed and should become part of clinical rehabilitation strategy throughout the VA and DoD health care systems, and the nation.
- Interface with the RR&D Technology Transfer Program and the Oregon Health & Science University Technology & Research Collaborations Office to facilitate partnering with appropriate private industry organizations to have innovative, clinically useful tools (e.g., AnalyzeOAE and AudioTest software applications, Computer Automated Tinnitus Psychoacoustics Testing system, Directional Microphone Test system, Method and Device for Non-invasive Analyte Measurement, OtoID device, and the PAL3000) translated into clinical practices at other VAMCs and across the nation.
- Prepare to host a third biennial international conference in Portland, OR during the fall 2007, and subsequently produce and distribute the conference sessions on DVD and video. Dr. Gabrielle Saunders and Ms. Carolyn Landsverk are co-chairing the conference entitled, 'Hearing Therapies for the Future'. The conference will be held on September 27-28, 2007 at the World Trade Center in downtown Portland, OR. The program committee is being chaired by Dr. Dawn Konrad-Martin.

- Record and broadcast additional Clinical Research Presentations using the VA Employee Education System satellite network and V-Tel system.
- Seek to further diversify and expand our research and development funding portfolio.
- Seek approval of funding to support the following NCRAR initiatives:
  - "A test to measure the impacts of dual-sensory impairment on daily function"
  - "Central auditory processing disorders associated with blast exposure"
  - "Clinical applications for time-compressed speech tests"
  - "Development of an automated test to assess the presence of tinnitus"
  - "DoD/VA joint incentive fund sharing initiative- hearing loss prevention program"
  - "Effects of hypertension on hearing loss in type 2 diabetic patients"
  - "Effects of training on central auditory function in multiple sclerosis"
  - "Frequency tuning and word recognition speed in older adults"
  - "Improving health literacy using a tinnitus education model"
  - "Individualized objective measures for the early detection of ototoxicity"
  - "Integrating auditory and visual information to improve hearing aids"
  - "Limiting inflammation in bacterial meningitis by targeting host immune pathways"
  - "Lipoic acid therapy for ototoxicity prevention"
  - "Non-invasive blood glucose monitoring by otoacoustic emissions"
  - "Otitis media impact on the inner ear"
  - "Pre-doctoral summer training program in auditory research"
  - "Progressive intervention program for tinnitus management"
  - "Randomized clinical study of group education for tinnitus intervention"
  - "Temporal resolution of cochlear and auditory nerve responses in older adults"
  - "The impacts of dual-sensory impairment on daily function"
  - "The veterans' hearing loss prevention program: improving hearing health"

Goals and Objectives Achieved

The NCRAR met and exceeded nearly all its 2006 goals and objectives while building VA research capacity through the recruitment, retention, support and mentoring of the next generation of VA rehabilitation researchers, rehabilitation engineers, and scholars. Paramount to the NCRAR's success in achieving its goals and building VA research capacity has been our ability to accommodate additional staff and associated research and development activities through the construction of dedicated VA Center of Excellence facilities and the provision of core, shared equipment and support services. The following are several of the NCRAR's most notable achievements during 2006:

- Completed the conversion of the NCRAR's website (www.ncrar.org) to a "va.gov" web domain (www.ncrar.research.va.gov).
- Conference proceedings from the NCRAR's fall 2005 biennial international conference entitled, "The Aging Auditory System: Considerations for Rehabilitation" were published in a special issue of *Seminars in Hearing* 2006;27(4):213-352. Drs. Nancy Vaughan and Stephen Fausti served as special guest editors of this issue that was devoted solely to publishing proceedings from the NCRAR conference.

- Construction of the 4th and final phase of the NCRAR's dedicated 21,000 square foot Center of Excellence facility was completed in March 2006.
- Completed the design, installation and performance verification of a state-of-the-art, fully-anechoic sound chamber facility, designed specifically for auditory research involving human hearing function. The chamber's unique, full-custom design provides extremely low ambient noise characteristics, a wide anechoic frequency range, and instrumentation to accommodate the full range of human hearing testing in support of current and future auditory rehabilitation research projects at the NCRAR. Current studies underway in the chamber include transducer characterization and hearing aid directionality investigations.
- Continued to work with the Department of Defense (DoD) Hearing Conservation Working Group (DoD HCWG) to move forward with the process of establishing the NCRAR as the U.S. Government Agency repository for receiving, protecting, utilizing and releasing data contained in the DoD's Defense Occupational Environmental Hearing Readiness System Hearing Conservation (DOEHRS-HC) database.
- Contributed significantly to the production of a patient-family education DVD entitled, "Ringing in the ears – what can I do about it", in collaboration with the VISN 8 Audiology & Speech Pathology Service, the National Audiology & Speech Pathology Service Program Office, and the VA Employee Education System.
- Dr. Levitt was honored as the 2006 recipient of the James Jerger Career Award for Research in Audiology, American Academy of Audiology.
- Dr. Saunders was selected and began serving as President-Elect of the Academy of Rehabilitative Audiology.
- Disseminated research results to professionals through 27 publications in scientific peer-reviewed journals and books, with an additional 43 manuscripts in press (18), under review (11), or in preparation (14), and 42 presentations made at professional conferences, meetings and symposia.
- Disseminated VA RR&D NCRAR research achievements to a broad spectrum of professional and lay audiences as a result of sponsoring ten clinical research seminars, as well as at roundtables, workshops, and community talks.
- Diversified and expanded its funding portfolio, particularly from extramural funding agencies.
- Hosted a Grand Opening Ribbon-Cutting Ceremony on June 27, 2006 to commemorate the completion of the NCRAR's newly constructed 21,000 square foot COE facility. The event was attended by over 200 individuals including staff from the VA Office of Research and Development, VA RR&D Service, VISN 20, Portland VAMC, and the Oregon Health & Science University, members of the DoD Hearing Conservation Workgroup, officers of Veteran Service Organizations, representatives of Oregon's Congressional Delegation, members of the NCRAR's National Advisory Board and Local Advisory Counsel, members of community groups who serve hearing impaired individuals, and veterans. The following individuals were speakers: Dr. Joel Kupersmith, VA Chief Research and Development Officer (CRADO); Dr. Robert Ruff, Acting Director, RR&D Service; Dr. Goeffrey McCarthy, Chief Medical Officer, VISN 20; Dr. James Tuchschmidt, Director, Portland VAMC; Dr. Leslie Hallick, Provost & Vice

President for Academic Affairs, Oregon Health & Science University; Dr. Michael Davey, ACOS, Research & Development Service; Dr. Dennis Smith, former VA CRADO and former Associate Director, NCRAR; and Dr. Allen Ryan, Director of Research & Professor of Otolaryngology, University of California at San Diego.

- Hosted Cynthia Fowler, PhD, as a Visiting (Auditory) Scientist; formalized arrangements to host Pamela Souza, PhD, as a future Visiting (Auditory) Scientist.
- Mentored and trained a talented group of auditory rehabilitation researchers, including the following career development awardees:
  - Frederick Gallun, PhD, Associate Investigator Awardee
  - Dawn Konrad-Martin, PhD, Advanced Research Career Development Awardee
  - Michelle Molis, PhD, Associate Investigator Awardee
  - M. Samantha Lewis, PhD, Research Career Development Awardee
  - Mitchel Turbin, PhD, Disability Supplement Awardee
- Proceedings from the NCRAR's fall 2005 biennial international conference sessions were broadly disseminated on DVD and video.
- Received approval of funding to support the following NCRAR initiatives:
  - "Auditory modeling of suprathreshold distortion in persons with impaired hearing"
  - "Clinical applications for time-compressed speech tests"
  - "Frequency tuning and word recognition speed in older adults"
  - "Identification of ambiguous vowel stimuli in noise by hearing-impaired listeners"
  - "Individualized objective measures for early detection of ototoxicity"
  - "Otitis media impact on the inner ear"
  - "Pre-doctoral summer training program in auditory research"
  - "Preliminary evaluation of a speech signal processing model: a pilot study"
  - "Preliminary evaluation of noninvasive blood glucose monitoring using otoacoustic emissions: a pilot study"
  - "Progressive intervention program for tinnitus management"
  - "PVAMC educational initiative
  - "Randomized trial of a brief patient-centered aural rehabilitation model"
  - "Temporal resolution of cochlear and auditory nerve responses in older adults"
  - "The ability to make multiple auditory judgments about non-speech stimuli"
- Initiated/fulfilled rehabilitation research and development collaborations with:
  - AudioFusion Inc., Winston Salem, NC
  - Australian Catholic University, North Sydney, Australia
  - Cleveland Clinic Foundation, Cleveland, OH
  - Bay Pines VA Healthcare System, Bay Pines, FL
  - DoD, U.S. Air Force Brooks City-Base, TX
  - DoD, U.S. Army Garrison, Fort Bragg, NC
  - DoD, U.S. Army Madigan Hospital, Fort Lewis, Tacoma, WA

- DoD, Army Audiology and Speech Center, Walter Reed Army Medical Center, Washington, DC
- Hearing & Speech Institute, Portland, OR
- House Ear Institute, Los Angeles, CA
- James A. Haley VAMC, Tampa, FL
- James H. Quillen VAMC, Mountain Home TN
- McMaster University, Ontario, Canada
- Oregon Health & Science University, Oregon Graduate Institute, School of Science & Engineering, Departments of Biomedical Engineering and Computer Science & Engineering, Portland, OR
- Petroff Audio Research, Inc., Marina Del Ray, CA
- Polytrauma and Blast-Related Injuries Quality Enhancement Research Initiative (QUERI), Rehabilitation Centers (Minneapolis, MN; Palo Alto, CA; and Tampa, FL)
- RR&D Center of Excellence on Restoration of Function in Spinal Cord Injury and Multiple Sclerosis, West Haven, CT
- RR&D Center for Aging Veterans with Vision Loss, Atlanta, GA
- Sensimetrics Corporation, Somerville, CA
- UCLA's Norman Cousins Center for Psychoneuroimmunology, Los Angeles, CA
- University of Alabama, Tuscaloosa, AL
- University of Regensburg, Regensburg, Germany
- University of Maryland, College Park, MD
- University of South Florida, Tampa Bay, FL
- University of Washington, Seattle, WA

Future Goals and Objectives

The NCRAR will continue to use its highly successful model of providing dedicated facilities, shared equipment, research and development support resources, and start-up needs for its core of auditory rehabilitation researchers to shape its future. We will continue to encourage and support the synergistic effect of multidisciplinary intellectual resources from core rehabilitation researchers, educators, rehabilitation engineers and key collaborators whose programs and projects are in turn supported through a variety of federal, public and private funding sources to maximally leverage the Center's core funding. Specific future goals and objectives include:

- Add an OAE recording feature to our AudioTest Software Suite to enable recording of SFOAE, DPOAE, and other types of OAE responses. We also will add a new Confidence Ranking feature to AudioTest Software Suite. This feature will enable subjects to indicate their level of confidence in response to questions presented through the AudioTest questionnaire interface.
- Continue development of the AnalyzeOAE software to incorporate new signal processing algorithms into OAE.
- Continue to build capacity through recruitment and mentoring of pre- and post-doctoral fellows, mid- and junior-level clinical research-scientists, scholars and rehabilitation

engineers who are deemed appropriate candidates for Research Career Development, Research Career Scientist, and other VA and non-VA research career development program opportunities including the following:

  - Career Development Award-2 candidates (F. Gallun, PhD; M. Molis, PhD; M. Samantha Lewis, PhD)
  - Career Development Transition Award candidate (D. Konrad-Martin)
  - Career Scientist candidate (G. Saunders, PhD)

- Develop independent study materials related to hearing impairment for the VA System-Wide Training program sponsored by the VA Employee Education System, including a 14-module, web-based tinnitus training course (20 hours of training) for VA audiologists (in collaboration with Paula Myers, PhD, James A Haley VAMC, Tampa, FL).
- Develop a patient education booklet for veterans with tinnitus in collaboration with Paula Myers, PhD, James A Haley VAMC, Tampa, FL.
- Development of a formal auditory research and rehabilitation engineering training program for medical school residents and fellows, and engineering students.
- Formalize partnerships to establish a Translational Hearing Research Center in Portland, OR.
- Further increase the diversity of leveraged funding.
- Host a third biennial international conference in Portland, OR during the Fall 2007, and subsequently produce and distribute the conference sessions on DVD and video. Dr. Gabrielle Saunders and Ms. Carolyn Landsverk are co-chairing the conference entitled, 'Hearing Loss: Techniques and Technology for Prevention'. The conference will be held on September 27-28, 2007 at the World Trade Center in downtown Portland, OR. The program committee is being chaired by Dr. Dawn Konrad-Martin.
- Implement a formal summer auditory research program for pre-doctoral AuD students.
- Initiate/expand research collaborations/clinical trials with:
  - Frye Electronics, Inc., Tigard, OR
  - Phonak Inc., Warrenville, IL
  - Sonitus Medical, Inc., Woodside, CA
  - Sound Pharmaceuticals, Inc., Seattle, WA
  - The Smith-Kettlewell Eye Research Institute, San Francisco, CA
- Initiate collaborations with vestibular/balance disorder rehabilitation researchers.
- Initiate new studies in rehabilitation of blast-related and noise-induced auditory injury, rehabilitation strategies based on neural plasticity of the central auditory system, and telehealth and web-based audiological services and programs.
- Interface with the RR&D Technology Transfer Program to facilitate partnering with appropriate private industry organizations to have innovative, clinically useful tools (e.g., AnalyzeOAE and AudioTest Software Suite applications, computer automated Tinnitus Evaluation System, Non-invasive Glucose Monitoring method and device using otoacoustic emissions, and OtoID device) translated into clinical practices at other VAMCs and the nation.

- Recruit and hire an accomplished electrophysiology researcher with expertise in human auditory neuroscience, electrophysiologic measurement of central auditory function, and plasticity of the central auditory system; and a hearing-aid researcher with expertise in hearing aid technology and fitting algorithms.
- Seek and obtain approval of funding for the following NCRAR initiatives:
  - "Central auditory processing disorders associated with blast exposure"
  - "Development of an automated test to assess the presence of tinnitus"
  - "DoD/VA joint incentive fund sharing initiative- hearing loss prevention program"
  - "Ecological momentary assessment in hearing research"
  - "Effect of training on central auditory function in multiple sclerosis"
  - "Integrating auditory and visual information to improve hearing aids"
  - "Limiting inflammation in bacterial meningitis by targeting host immune pathways"
  - "New strategies for sound-based tinnitus relief"
  - "Noninvasive blood glucose monitoring using otoacoustic emissions"
  - "Prevention of cisplatin ototoxicity with the antioxidant α-lipoic acid"
  - "Supplementing hearing aids with computerized auditory training"
  - "The impacts of dual-sensory impairment on daily function"
  - "The Veterans' Hearing Loss Prevention Program: Improving Hearing Health"
  - "Using chronic pain models to develop tinnitus evaluation and treatment methods"
- Seek and obtain external funding to support education and training program activities.
- Sponsor additional clinical research seminars, and work with the VA Audiology and Speech Pathology Program Office and the VA Employee Education System to develop and produce additional satellite broadcasts using the VA Employee Education System satellite network and V-Tel systems.
- Work to develop hearing loss prevention and hearing conservation programs and practices that should become part of clinical rehabilitation strategy throughout the VA and DoD health care systems, and the nation.

Plan Adjustments

Work at the NCRAR serves a high-priority area relevant to the rehabilitation needs of veterans, among whom hearing loss and tinnitus are the first and second most common individual disabilities. The prevalence of auditory impairments creates a tremendous demand for auditory rehabilitation services, and provides a broad patient base for clinical trials, strategies and outcomes measures. To meet the needs of current and future veterans, the NCRAR will expand its focus on rehabilitative auditory research and development by extending established lines of research while integrating new research directions in the following priority areas: 1) rehabilitation of blast-related and noise-induced auditory injury; 2) rehabilitation strategies based on neural plasticity of the central auditory system; and 3) telehealth and web-based audiological services and programs.

III. PROJECT REPORTS

VA Submissions (n = 9; total requested funding = $5,503,700)

Title: Career Development Award – 2

Principal Investigator: Frederick Gallun, PhD

Mentors: Marjorie Leek, PhD; Stephen Fausti, PhD

Funding Agency: VA RR&D Total Requested Funding: $546,000

Timeframe: Four years requested (pending outcome of March 2007 merit review)

Objectives: This plan has as its goal the transition of Dr. Gallun to the role of independent researcher at the NCRAR. Associated with this goal is a research plan focused on understanding (through experimentation and computational modeling) the cognitive processes of combining and selecting auditory information.

Research Plan: Experimental work will involve four groups of 30 normally-hearing and 30 hearing-impaired listeners (both divided between older and younger listeners) who will participate in four cycles of experimental testing and computational modeling. Mentors will be Drs. Fausti and Leek from the NCRAR, Dr. Colburn from Boston University and Nathaniel Durlach of M.I.T. The research and mentoring will involve 1) the behavioral experiments, 2) the design of a computational model focused on the problem of combining the binaural model of multicomponent sound processing by Woods and Colburn (1992; Woods, 1995) with the frequency-selectivity model of Durlach et al. (2005) and 3) using the predictions and explanations provided by the model to generate a more complete theoretical description of the difficulties experienced by older and hearing-impaired listeners in complex auditory environments.

Methods: The task of the listeners will always involve detection of a 2 kHz amplitude-modulated tone in the presence of various masking tones. In different conditions, maskers will differ from the target in terms of harmonicity, amplitude-modulation or binaural relationships. The basic computational model will describe and predict how frequency-weighting functions are applied to the binaural information available across the frequency spectrum of the stimulus. Extensions of the model will involve sensitivity to amplitude modulation and harmonicity. The project will require stages of model building followed by stages of experimental testing, with each stage influencing the next until accurate predictions are achieved.

Findings to date: The study has just been submitted for review; therefore there are no findings to report at this time.

Title: Central auditory processing disorders associated with blast exposure

Principal Investigator: Marjorie Leek, PhD

Co-Principal Investigator: Stephen Fausti, PhD

Funding Agency: VA RR&D Total Requested Funding: $528,400

Timeframe: Three years requested (pending outcome of March 2007 merit review)

Objectives: The incidence and nature of central auditory dysfunction in warfighters who are exposed to high-explosive blasts while serving in combat have not been clearly determined. Using a battery of behavioral and neurophysiological tests, we propose to evaluate central auditory function and vestibular function in warfighters who have been exposed to explosive blasts. We will collaborate with the Army Audiology & Speech Center at Walter Reed Army Medical Center (WRAMC). The research will be coordinated at the National Center for Rehabilitative Auditory Research (NCRAR) at the Portland VA Medical Center, and data collection will take place both at the NCRAR and at WRAMC. The study objectives are to determine whether there are certain central auditory processing disorders that are often associated with exposure to high-explosive blasts, and whether there is spontaneous recovery of central auditory function with time after blast exposure, how much recovery may be expected, and how rapidly it occurs.

Research Plan: From 80-100 patients will be recruited at Walter Reed Army Medical Center to participate in this research study. Soldiers returning from OIF/OEF are identified at intake as having been exposed to high-explosive blasts. A battery of central auditory processing tests will be administered to participants as soon as possible after their arrival at WRAMC. Those patients who demonstrate aspects of central auditory processing disorder will be invited to participate in further testing nine months later. Those subjects will be brought to the NCRAR at the Portland VA Medical Center for two to three days of auditory testing. They will undergo the same battery of central auditory tests as they experienced at WRAMC. Control subjects will be recruited who do not have a history of blast exposure and who are matched in age, gender, and audiometric configuration with the experimental subjects. Control subjects will be tested at the NCRAR site.

Methods: The battery of tests includes behavioral tests to assess dichotic and temporal processing, neurophysiologic measures, vestibular testing to indicate any dysfunction to balance and vestibular processes, and tinnitus evaluated by questionnaire. Results of each test will be evaluated against norms established in the literature and against performance by control subjects. Differences will be analyzed using t-tests comparing experimental and control scores, as well as correlations among scores on the various tests within the battery.

Findings to date: There are no findings that have been published regarding the incidence of central auditory processing disorders in this population.

Title: Development of an automated test to assess the presence of tinnitus

Principal Investigator: James Henry, PhD

Funding Agency: RR&D Total Requested Funding: $590,300

Timeframe: Three years requested funding (approved, pending start date and release of funds)

Objectives: Veterans can claim tinnitus (ringing in the ears) as a service-connected disability, which is occurring with alarming frequency. As of September, 2005, over 339,000 veterans were service-connected for tinnitus, which equates to about $418,000,000 per year in tinnitus disability compensation (VA Office of Policy and Planning). Although about 50,000 tinnitus-disability claims are being approved annually, veterans do not undergo any formal testing to document the actual existence of their tinnitus. We have developed computer-automated methodology to conduct a battery of clinical tests to quantify various psychoacoustic aspects of tinnitus. We have used this methodology to test individuals who do not have tinnitus to determine how they respond to these tests. Results have shown characteristic differences between people who do have tinnitus versus those who do not. These preliminary data suggest that a more formalized test can be developed to test for the existence of tinnitus. The primary objective of the proposed project is to develop a fully documented test for identifying the presence/absence of tinnitus. The test is referred to as the Tinnitus Perception Test (TPT).

Research Plan: A preliminary project will be conducted to assess two procedures that are expected to improve the effectiveness of the TPT: 1) Bekesy audiometry (automated audiometry that has been used to detect hearing-loss malingering); and 2) the forced-choice double staircase (FCDS) procedure (the only test that has been shown to obtain reliable measures of tinnitus pitch). Throughout the proposed study period, the automated system will continue to be beta-tested at four VA Audiology clinics so that system modifications can be made to optimize clinical testing performance.

Methods: *Project 1* (years 0-1) will require software and hardware engineering to incorporate Bekesy and FCDS capabilities into the automated system. Forty subjects with tinnitus and 40 without tinnitus will each be tested with these procedures over two sessions. *Project 2* (years 1.0-3.0) will involve development of the TPT and evaluation of the prediction model with 320 subjects (160 with tinnitus and 160 without). For *Project 3* (all sites—years 0-3), four VA Audiology clinics will beta-test the system with 300 veteran patients. Based on feedback from the audiologists, system refinements will be made and incorporated at each site on an ongoing basis.

Findings to date: The study is pending outcome of scientific merit review.

Title: Effect of training on central auditory function in multiple sclerosis

Principal Investigator: Dennis Bourdette, MD

Co-Principal Investigator: Nancy Vaughan, PhD

Co-Investigators: M. Samantha Lewis, PhD; Debbie Wilmington, PhD

Funding Agency: VA RR&D Total Requested Funding: $595,200

Timeframe: Three years requested funding (approved, pending start date and release of funds)

Objectives: Multiple sclerosis (MS) is an inflammatory disease of the central nervous system that affects approximately 26,000 veterans (MS Centers of Excellence, 2004). Although peripheral hearing loss is rare in this population, 40% to 60% of MS patients with normal pure-tone thresholds present with hearing difficulty especially in backgrounds of noise. We hypothesize, that this may be due, in part, to central auditory processing deficits caused by focal loss or destruction of myelin sheath (demyelination) in the auditory nervous system. With these thoughts in mind, the purpose of the proposed investigation is to assess thoroughly the central auditory processing (CAP) deficits for patients with MS. Additionally, since there is evidence that the brain is plastic and capable of being retrained (Jancke, Gaab, Wustenberg, et al, 2001), this investigation also will examine whether or not the implementation of an auditory training program can improve central auditory function in patients with MS.

Research Plan: In a previous study, test materials were developed to evaluate auditory function in MS patients and in patients who do not have MS. For the proposed extension of that study central auditory function will be further characterized and potential rehabilitative strategies will be examined. Experimental subjects will be recruited from the Portland VAMC, Oregon Health & Science University and from the general community. Control subjects will be matched to the subjects with MS with respect to age, gender and audiometric configuration.

Methods: Five general types of evaluations will be employed over multiple study sessions. First, a neurologist will review the subject's medical history and perform a neurologic exam to confirm MS diagnosis. Second, peripheral auditory function will be evaluated using a standard set of routine audiometric tests. Additionally, subjects will complete a case history and series of hearing handicap inventories. Third, a battery of behavioral procedures will be used to characterize central auditory processing. Fourth, auditory evoked potential studies will be performed. Emphasis here will be upon evoked potentials whose putative neural generators lie within the central auditory nervous system. Fifth, subjects will receive functional MRI evaluation to determine site and amount of neural activation during dichotic listening. After evaluation, subjects will be enrolled into a home-based auditory training program to evaluate possible improvements in auditory function. After training, the aforementioned evaluation procedures will be repeated.

Findings to date: This study has been approved, however we are awaiting notification of a start date and release of funding. There are therefore no findings to report at this time.

Title: Prevention of cisplatin ototoxicity with the antioxidant α-lipoic acid

Principal Investigator: Stephen Fausti, PhD

Co-Principal Investigator: Debra Wilmington, PhD

Funding Agency: VA RR&D Total Requested Funding: $650,100

Timeframe: Three years requested funding (approved, pending start date and release of funds)

Objectives: Therapeutic treatment with the chemotherapeutic drug cisplatin (CDDP) can produce cochlear damage in 60% to 70% of patients, often resulting in irreversible hearing loss. The ototoxic effects of CDDP are mediated by the formation of reactive oxygen species which cause oxidative stress resulting in apoptotic cell death of the outer hair cells. Antioxidant treatment has been successful in a number of animal models as a protective pharmacological intervention for ototoxic-induced hearing loss. The proposed translational study will link the successful use of otoprotectants in animals to the establishment of clinical protocols in patients receiving ototoxic medications. Behavioral conventional and high-frequency audiometry and their correlation with laboratory markers of oxidative stress will be used to determine the ability of alpha-lipoic acid therapy concurrent with administration of CDDP to minimize the incidence, delay the onset, and/or reduce the magnitude of ototoxic hearing loss.

Research Plan: The effectiveness of antioxidant therapy concurrent with CDDP treatment will be evaluated in a randomized double blind placebo study by assessment of behavioral conventional and high-frequency pure-tone behavioral thresholds and will be correlated with malondialdehyde (MDA) levels as a marker of oxidative stress and serum concentrations of lipoic acid.

Methods: Subjects will include human patients who are scheduled to receive CDDP. One week prior to treatment, plasma concentrations of MDA and lipoic acid concentrations will be measured to establish a baseline level of oxidative stress. Patients will then be given either the antioxidant therapy or the placebo to be taken orally every day during CDDP treatment and continued for one month post-treatment. MDA and lipoic acid levels will be obtained at the beginning of each CDDP treatment to measure the improvement in oxidative state and serum concentration of lipoic acid. Creatinine clearance (24 hour urinary creatinine/plasma creatinine) will be used at this time to measure renal function.

One week prior to antioxidant and drug administration, behavioral audiometric thresholds will be obtained to serve as the baseline audiogram that will be used as the gold standard for hearing sensitivity measurement during the subject's enrollment. Behavioral thresholds will be identified for frequencies from 500 Hz to 20 kHz. From the obtained thresholds, the behavioral sensitive range for ototoxicity (SRO) will be determined. These seven frequencies will constitute the behavioral SRO to be monitored for each test session, including follow-up. During and at one and three months post-treatment, hearing sensitivity in the SRO will be measured to detect early changes in hearing sensitivity.

Findings to date: This study has been approved, however we are awaiting notification of a start date and release of funding. There are therefore no findings to report at this time. We expect the outcomes of this investigation may permit the specification of an antioxidant therapy which can be used as part of a clinical protocol to reduce hearing loss associated with treatment due to the chemotherapeutic drug Cisplatin. Furthermore, effective protective therapies for ototoxicity could also be used for patients receiving aminoglycoside antibiotics and other chemotherapeutic drugs.

Title: Integrating auditory and visual information to improve hearing aids

Principal Investigators: Marjorie Leek, PhD; Peter Jacobs, MSEE

Co- Investigators: Deniz Erdogmus, PhD; Eric Wan, PhD; Michelle Molis, PhD

Funding Agency: VA RR&D Total Requested Funding: $465,100

Timeframe: Three years requested (submitted June 2006 – not funded, currently in revision)

Objectives: Allowing listeners to observe the face of a speaker enhances the ability to understand speech in noise. One way in which visual information contributes to speech understanding is through the common and complementary modulations occurring in the auditory and visual signals that may be integrated in the central auditory system of the listener. The time-linked characteristics of auditory and visual information reflected in the speech signal form the basis for the algorithms to be developed and implemented into a new technology to improve speech intelligibility and sound localization in noisy environments. Mutual information (MI) carried by the visual and the auditory signals of a talker will be used to develop real-time filtering to reduce irrelevant sound in the environment and enhance the target speech message. We propose to develop and test three new real-time algorithms that will greatly improve the functionality of a hearing-aid: 1) an audio-visual feature extraction and noise reduction algorithm; 2) an audio-visual sound localization and enhancement algorithm; and 3) an algorithm that uses auditory and visual cues to perform real-time automatic speech recognition (ASR).

Research Plan: The first algorithm we will develop will perform audio-visual feature extraction and noise reduction (FENR). The FENR algorithm will be developed using techniques from information theory and optimization to create a set of audio and video filters. Noisy audio will be passed through the FENR audio filter to improve SNR. The second development of this proposal is the sound localization algorithm (SLA). The video filter output of the FENR algorithm will provide information about the location of sound sources in the environment which the SLA will use to extract audio cues necessary for sound localization including interaural time difference (ITD), interaural level difference (ILD), total level, spectral cues, and reverberation patterns. These cues will be enhanced and exaggerated using SLA. Finally, we will use visual cues to develop an algorithm for doing real-time ASR (AV-ASR) with group delays less than 20 ms.

Methods: The project will include two areas of research: development and testing. After developing the three algorithms, each one will be tested on simulations and on patients with hearing and vision loss. The FENR algorithm may be evaluated using an off-the-shelf ASR machine's ability to recognize speech data before and after the enhancement, and subsequently on patients with both hearing and dual-sensory hearing and vision loss. The SLA algorithm will be developed with the help of our 24-speaker sound localization and test system located within an anechoic chamber at NCRAR, and will be tested on patients with hearing loss and with dual-sensory impairment. We will use a coupled HMM architecture to integrate the audio and video information and to recognize context-independent phonemes within a short time frame less than 20 ms. The AV-ASR algorithm performance will be compared with an off-the-shelf non real-time ASR package.

Findings to date: A preliminary FENR algorithm has been designed at the NCRAR in conjunction with the Adaptive Systems Lab at the Oregon Health & Science University. We have demonstrated feasibility of the algorithm using a simulated data set and a mathematical model written in Matlab. Improvements in signal-to-noise ratio are expected to be in the range of 5-9 dB under ideal conditions. This would provide a significant improvement in the ability of a listener to extract a speech signal from ongoing noise and babble.

Title: New strategies for sound-based tinnitus relief

Principal Investigator: James Henry, PhD

Funding Agency: VA RR&D Total Requested Funding: $545,800

Timeframe: Three years requested (pending outcome of March 2007 merit review)

Objectives: Tinnitus masking (TM) is a method of treatment that uses sound in specific ways to provide immediate relief from tinnitus. The sense of relief can be accomplished with any sound, at any level, and using any type of sound-producing device. Optimal treatment involves the use of ear-level devices that deliver masking noise directly to the ears. Ear-level devices allow patients to receive relief at any time and in any circumstance. Although TM is effective for many patients, the method is limited by the ear-level devices that are capable only of generating broadband noise. This limitation prevents the use of digitally synthesized sounds, including those that have been designed specifically to facilitate tinnitus relief. In addition, treatment with TM takes advantage of the residual inhibition (RI) effect (reduction in tinnitus loudness following masking noise) by encouraging patients to attempt to achieve RI on their own. There are no clinical algorithms, however, for determining the acoustic factors that produce the greatest RI effect. Our working hypothesis is that the efficacy of TM can be improved by systematically identifying sounds that optimize RI and tinnitus relief. Once identified, these sounds can be used to provide ongoing treatment through the use of wearable equipment. The planned studies will characterize these sounds for each subject and evaluate their efficacy when used as part of a daily treatment procedure.

Research Plan: Computerized algorithms will be developed to present sounds systematically to 100 subjects who experience bothersome tinnitus. Using the tinnitus evaluation system (TES) that we developed, the automated algorithm procedures will identify sounds that are optimum for achieving RI and tinnitus relief. Those sounds will then be uploaded to ear-level devices, which will allow the subjects to receive daily treatment with the sounds. Recent technological developments have made available wearable devices that can be used for this purpose.

Methods: For Study 1, subjects will complete psychoacoustic testing to systematically identify the sounds and parameters of those sounds that produce maximum RI. Study 2 will involve similar testing to identify sounds that are most effective in reducing the annoyance caused by tinnitus. For Study 3, the sounds that were selected in Studies 1 and 2 will be made available in wearable listening systems to determine the feasibility of using this technique to achieve sound-based tinnitus relief. Using a two-period crossover design, subjects will listen to the RI sounds for 2 weeks, and the tinnitus-relief sounds for 2 weeks (with a 1-week "washout" period). A tinnitus outcome questionnaire will be completed at the beginning and end of each 2-week treatment period to obtain preliminary data regarding the efficacy of this treatment technique.

Findings to date: The study is pending outcome of scientific merit review.

Title: Supplementing hearing aids with computerized auditory training

Principal Investigator: Harvey Abrams, PhD

Co-Principal Investigators: Gabrielle Saunders, PhD; Richard Wilson, PhD

Funding Agency: VA RR&D Total Requested Funding: $928,600

Timeframe: Three years requested (pending outcome of March 2007 merit review)

Objectives: Research data clearly demonstrate many beneficial treatment effects from hearing aid intervention, however, wide individual variation in treatment outcome is also documented. To improve the outcomes of hearing aid intervention, other components of auditory rehabilitation can be considered. With the advent of easy access to home computers home-based computerized adaptive auditory training is a possibility. There are no data examining whether auditory training can improve outcomes of standard-of-care hearing aid intervention, particularly in the VA population who differ from the general adult hearing loss population, in many self-report domains of hearing aid outcome. In this study we will assess the relative efficacy of supplementing standard-of-care hearing aid intervention provided to adult veterans with hearing loss, with auditory training administered via a commercially available computer-administered auditory training program; and, with a "placebo" auditory training paradigm, consisting of "directed listening" activities for specified periods of time.

Research Plan: The study will take place at three test sites. The primary site is the Bay Pines VA Healthcare System, in Bay Pines Fl, with the National Center for Rehabilitative Auditory Research at the Portland VAMC, Portland OR and Mountain Home VAMC in TN as participating sites. Equal numbers of participants will be tested and recruited at each site. Subjects will be hearing aid users with at least 4-weeks experience with use. The study is a multi-site, randomized controlled, parallel group clinical trial to assess the efficacy of at home PC-based auditory training as a supplement to standard-of-care hearing aid intervention in veterans treated for hearing loss, with or without previous hearing aid experience. Participants will be randomly assigned to one of three groups: Group 1 participants will receive standard-of-care hearing aid intervention and complete the 4-week auditory training program. Group 2 participants will receive only standard-of-care hearing aid intervention. Group 3 participants will receive standard-of-care hearing aid intervention and complete 4-weeks of placebo auditory training, consisting of directed listening to books-on-tape. Short term outcome immediately post-training and longer term outcome at 6-month post-training will be evaluated and compared across groups.

Methods: Participants will attend four test sessions. During Session 1 the informed consent process will be completed, baseline assessments will be made to ensure participants meet the study inclusion criteria, unaided testing of predictor variables will be completed and all hearing aids will be assessed for correct functionality. Subjects will then be randomly assigned to their study group. Session 2 will occur 4 weeks after session 1. During this visit, performance on the primary and secondary outcome measures will be assessed, as will performance on predictor variables. Participants in Groups 1 and 3 will then receive training in the use of the auditory training or directed listening programs. Session 3 will occur at the end of the 4-week experimental training period. During this session all participants will be retested on the primary and secondary outcome measures to assess short-term intervention outcome. Session 4 will occur at 7-months post-study enrollment (i.e. 6-months post training completion for Groups 1 and 3), when participants will be retested on all outcome measures to examine long-term outcome.

Findings to date: None; this is a new application still pending outcome of scientific merit review.

Title: The impacts of dual-sensory impairment on daily function

Principal Investigator: Gabrielle Saunders, PhD

Co-Principal Investigator: Katharina Echt, PhD

Funding Agency: VA RR&D Total Requested Funding: $654,200

Timeframe: Three years requested (pending outcome of March 2007 merit review)

Objectives: Surveys show that as many as 21% of adults over 70 years of age have dual sensory impairment (DSI) - a combination of hearing loss and vision loss. However, the VA Dual Sensory Loss Consensus conference of 2004 revealed a lack of research regarding the functional impacts of DSI on daily life, and on how the combined effects of vision and hearing impairments affect everyday function. The goal of this proposal is to examine the impact of DSI on objective and subjective measures of everyday function with the overarching goal of developing rehabilitation strategies that are empirically informed. To this end, we will use a performance-based measure (Observed Tasks of Daily Living-Revised, ODTL-R) and a self-report measure (the World Health Organization Disability Assessment Schedule II, WHO-DAS II) to characterize the impact of DSI, while accounting for factors including severity and duration of impairments, cognition, education, age, and co-morbidities.

The following questions will be addressed. Q1: How does dual sensory impairment impact everyday function as measured by a standardized performance instrument, the ODTL-R? Q2: How do reports of activity limitations/participation restrictions by individuals with DSI differ from normative data obtained from individuals without sensory impairment, as measured by the WHO-DAS II? Q3: Will difficulties measured and reported by individuals with DSI be influenced by severity and duration of the sensory impairments, cognitive status, education, age, and comorbidities? Q4: Will there be different subgroups of individuals with DSI who exhibit similar functional impacts and thus for whom different interventions and rehabilitation strategies are indicated?

Research Plan: This project is a collaborative study between investigators at the National Center for Rehabilitative Auditory Research in Portland OR, and the Center of Excellence for Aging Veterans with Vision Loss in Atlanta GA. One hundred twenty five individuals will participate at each site. All participants will have dual sensory impairment. The study will require two visits to the laboratory.

Methods: Following the consent process, subjects will undergo tests of hearing loss, vision loss and cognitive function to determine whether they meet the study criteria. Subjects meeting the criteria will complete questionnaires regarding the impact of hearing loss and vision loss on daily function, complete a performance-based measure of function and additional measures of cognitive status. Along with analyses examining the impact of DSI upon function and self-report, discriminant function analysis will be used to extract subgroups of individuals for whom different treatment and rehabilitation strategies will be developed.

Findings to date: The proposed study has not begun therefore there are no findings to report at this time.

VA Approvals (n = 10; total funding received = $2,181,805)

Title: Associate Investigator Award

Principal Investigator: Frederick Gallun, PhD

Mentors: Marjorie Leek, PhD; Stephen Fausti, PhD

Funding Agency: VA RR&D Total Approved Funding: $85,556

Timeframe: 11/01/06-10/31/07

Objectives: The goal of this award is to provide interim support for Dr. Gallun as he applies for funding under the VA RR&D Career Development program.

Training Plan: Drs. Leek and Fausti will serve as mentors in the grant writing process and in moving forward Dr. Gallun's research experience and familiarity with the goals and methods of rehabilitation research.

Methods: Individual meetings with the two mentors will supplement the grant writing process and drafts of the career development grant will be read and critiqued by the mentors. Simultaneously, Dr. Gallun will interact with the other PIs at the NCRAR in order to learn from them about their areas of expertise. In this way, Dr. Gallun will progress towards the ability to generate and carry out an independent research program that is appropriate to the translational goals of the NCRAR.

Progress to date: The initial submission of the Career Development Award – 2 application occurred on December 15, 2006 after intensive consultation between Dr. Gallun and the two mentors. Since that time, Dr. Gallun has begun one-on-one tutorials with Dr. Leek concerning spectro-temporal modulation, Dr. Konrad-Martin regarding the use of otoacoustic emissions as a clinical tool, and visiting scholar Dr. Pamela Souza on the impact of hearing-aid compression on temporal envelopes. All three of these conversations have proceeded to the level of planning collaborative research projects. One has reached the point of stimulus design and the collaboration with Dr. Souza has proceeded to the analysis of previously collected data.

Title: Associate Investigator Award

Principle Investigator: Michelle Molis, PhD

Mentor: Marjorie Leek, PhD

Funding Agency: VA RR&D Total Approved Funding: $152,516

Timeframe: 02/01/06 – 01/31/08

Objectives: The Associate Investigator Award provides Dr. Molis with an opportunity to receive research training and mentoring in the area of speech perception by hearing-impaired individuals. This training will help her to develop as an independent research investigator.

Training Plan: The training program for Dr. Molis encompasses formal and informal learning, supervised research, and independent research. Dr. Molis continues to work closely with Dr. Leek in the development and implementation of research activities that address the temporal processing of complex sounds, like speech, in individuals with hearing loss.

Methods: The methods and techniques used in investigations of speech perception by hearing impaired individuals include speech synthesis, statistical analyses, and computer modeling of the response of the impaired auditory system to speech and other complex sounds.

Progress to date: Since receiving her Associate Investigator award, Dr. Molis has made progress in all areas of her training program. She has worked together with her mentor, Dr. Marjorie Leek, to set up a new speech perception and hearing research laboratory at the National Center for Rehabilitative Auditory Research at PVAMC. She has also worked to prepare studies from Dr. Leek's NIH grant by writing a computer program to generate and present stimuli and collect subject responses.

Based her own line of research (in collaboration with Dr. Leek) Dr. Molis presented a poster on the perception of ambiguous vowel stimuli by hearing-impaired listeners at the Spring 2006 meeting of the American Auditory Society. A manuscript based on these results is in preparation. Dr. Molis wrote a successful grant proposal for an Early Clinical Investigator award through the Oregon Health & Science University (OHSU) Medical Research Foundation. The focus of that proposal is the perception of vowel by hearing-impaired listeners in the presence of a competing background noise.

In collaboration with Dr. Jennifer Tufts of the University of Connecticut, she carried out a study of the perception of roughness by hearing-impaired listeners. The results of this study were reported at the Spring 2006 meeting of the Acoustical Society of America and a manuscript is in preparation. Further, she has begun collaboration with the Center for Spoken Language Understanding at the Oregon Graduate Institute School of Science and Engineering (OGI) that will result in an NIH grant submission in Spring 2007.

In the spring, she attended a course offered at OGI titled 'Introduction to Digital Signal Processing' and is currently attending the Vollum Writing Program offered through the OHSU Research Funding and Development Service.

Title: Clinical applications for time-compressed speech tests

Principal Investigator: Marjorie Leek, PhD

Funding Agency: VA RR&D Total Approved Funding: $518,900

Timeframe: 10/01/06 – 09/30/09

Objectives: The incidence of hearing loss increases substantially with age making it the third most common chronic condition after high blood pressure and arthritis in older Americans. The most common complaint of people with hearing loss is that speech is particularly difficult to understand in background noise, even with a hearing aid. Older listeners have even greater difficulty than younger listeners with similar hearing loss. In addition to hearing loss, other non-auditory factors may be involved in the ability of a listener to benefit from certain hearing aid amplification strategies in various background competitions. One suggested reason for poor compliance is the limited ability of older listeners to benefit from cognitively demanding complex signal processing algorithms available in modern hearing aids (Lunner, 2003; Plomp, 1994). An efficient method of determining how individual cognitive status might affect potential hearing aid benefit would be an important clinical tool to facilitate appropriate selection of hearing aids. The primary objective of this study is to determine whether an efficient speech recognition test known to be associated with cognitive deficits in older listeners can be used as an indicator of potential hearing aid benefit.

Research Plan: The proposed investigation will examine the interaction of working memory and hearing aid compression method on speech recognition in three types of background competition for older listeners. There will be two phases to this study. In the first phase, elderly adults will be evaluated on a number of tests of auditory processing, cognitive capacity, and compressed speech. Subjects who score in the top and bottom quartiles on the compressed speech test will be invited to participate in phase 2 of the study. In the second phase, these subjects will be tested on several speech-in-noise tests under three conditions of hearing aid settings. It is hypothesized that subjects who score high on time-compressed speech will be successful users of hearing aids with fast compression characteristics, while low-scorers will require different compression settings.

Methods: The tests will begin with a basic audiological workup including auditory processing tests of temporal resolution. The time-compressed speech (TCS) test along with neurocognitive tests and two auditory temporal processing will then be administered within the same session. In the second phase of the experiment, the HINT test will be used in each of the three competing conditions for each of three types of amplification: one channel linear, two channel with fast time-compression constants and two channel with slow time compression constants

Findings to date: There are no findings to report yet. Phase 1 data collection is currently underway.

Title: Preliminary evaluation of non-invasive blood glucose monitoring using OAE: a pilot study

Principal Investigators: Marjorie Leek, PhD; Peter Jacobs, MSEE

Funding Agency: NCRAR Total Approved Funding: $250

Timeframe: 02/01/06 – 06/30/07

Objectives: As part of a research program that is being submitted for funding to the NIH, rehabilitation researchers at the NCRAR obtained approval to initiate the development of a portable handheld device that patients and clinicians may use to monitor blood glucose noninvasively without the need for painful finger sticks. The objective of this pilot project is to collect sufficient preliminary data to support the development of an NIH research proposal to determine the extent to which blood glucose levels in type I diabetic subjects can be measured using masked evoked otoacoustic emissions (OAE). The OAE is a sound generated by the cochlea that provides a noninvasive test of the cochlear mechanical response to acoustic stimuli. There is evidence that suggests that OAE amplitudes and latencies correlate with glucose. Our hypotheses are that: 1) amplitude and latency measures within an OAE will correlate with blood glucose levels in healthy non-diabetic and in type I diabetic subjects; and 2) there will be a more pronounced correlation when presenting contralateral masking noise while evoking the OAE.

Research Plan: To achieve our objective and confirm our hypotheses, we propose the following specific aims: 1) determine whether certain types of audio stimuli and masking conditions evoke OAEs from the cochlea that correlate with blood glucose levels; and 2) develop parametric and non-parametric models that could be used to predict blood glucose levels in a diabetic patient given certain independent variables extracted from the OAE measurement, including amplitude and latency.

Methods: Several type I diabetics who take insulin on a daily basis will serve as the experimental group of subject in this study. The subjects will be screened to determine which audio stimuli patterns evoke optimal OAE responses to contralateral noise, ipsilateral noise, or both noise types. The subjects will then undergo a glucose tolerance test (GTT) to manipulate their blood glucose levels over a clinically wide range of values. Evoked OAEs will be recorded regularly throughout the GTT. Results will be collected on consecutive days to assess short-term drift in the OAE response, and again approximately one month after the initial testing to determine long-term drift in the OAE responses. Data analysis will help determine whether a correlation exists between OAE measures and the subjects' blood glucose levels relative to control subjects. Mathematical models predicting glucose will be developed and validated using OAE measures.

Findings to date: A preliminary experiment was done on one healthy, non-diabetic subject. OAEs were measured during a GTT under contralateral noise masking, forward masking, and no masking conditions. OAEs evoked during contralateral and forward noise masking conditions correlated with glucose in a multivariable linear regression between glucose levels and OAE amplitudes / latencies (R-Squared = 0.76). A less significant correlation was observed when OAEs were evoked without contralateral masking. The preliminary findings support our hypothesis and provide justification for further pilot data collection.

Title: Preliminary evaluation of a speech signal processing method: a pilot study

Principal Investigators: Marjorie Leek, PhD; Peter Jacobs, MSEE

Funding Agency: NCRAR Total Approved Funding: $280

Timeframe: 02/01/06 – 06/30/07

Objectives: As part of a research program that is being submitted for funding to the VA RR&D Service, engineers at the NCRAR have initiated the development of a signal processing algorithm that uses both the audio and the video channels of recorded audio-visual speech to determine common information. The non-common information ("noise") is then filtered out in the audio channel, leaving a clearer, enhanced speech signal. The objective of this study is to measure understanding of processed and unprocessed speech by a small number of normal-hearing and hearing-impaired patients to estimate the potential benefit of this signal processing method, and to provide pilot data for the Merit Review grant resubmission.

Research Plan: Although current hearing aids incorporate several signal processing strategies to improve speech understanding by people with hearing loss, even the best processing schemes do not resolve patients' difficulties recognizing speech in a noisy background. The signal processing algorithm developed at the NCRAR using both video and audio information produces a much improved signal-to-noise ratio over the audio channel, suggesting as much as a 6-dB or greater improvement after processing. However, convincing pilot data are needed to show the translation of that signal-to-noise improvement to better speech understanding by hearing-impaired listeners. Up to seven patients with mild-to-moderate hearing loss and seven normal-hearing subjects will be recruited to participate in this pilot study. Subjects will listen over earphones to recorded sentences in a background noise, played at a comfortable listening level. After each sentence, the subject will repeat the sentence he/she has just heard, and the responses will be noted by the experimenter. One set of fifty sentences will be unprocessed, normal conversational speech. A second set of sentences will be processed according to the newly-developed signal processing scheme. All of the testing will be accomplished in one two-hour session, with rest breaks taken by the subject as needed.

Methods: Sentences used in this study will be taken from a 720-item corpus of sentences developed specifically for speech intelligibility testing (IEEE/Harvard). Simultaneous audio and video recordings of the sentences will be processed through the signal processing algorithm. Each sentence contains five key words. The total number of key words correctly repeated by each subject in the unprocessed and the processed listening conditions will be scored. A repeated-measures ANOVA on the scores for each group and the two listening conditions will indicate whether the signal processing significantly improved performance in the same way for normal-hearing and hearing-impaired listeners. These data will be reported in a grant submission to support a full study of speech enhancement through the use of this audio-visual signal processing algorithm. It should be noted that this methodology is nearly identical to routine clinical audiometric testing. Differences are that in the clinic, other sounds in addition to speech are tested, typical testing time is less than the two hours expected for this pilot study, and the speech stimuli come from different test corpuses (i.e., other published sets of speech stimuli.)

Findings to date: Earlier work relating improvements in signal-to-noise ratio (SNR) and human performance in terms of percent correct understanding of speech suggest that a 3-dB improvement in SNR may result in more than 30 percentage points of improvements in speech understanding. Only testing of human subjects can estimate the potential effectiveness of this processing.

Title: Progressive intervention program for tinnitus management

Principal Investigator: James Henry, PhD

Co-Principal Investigator: Paula Myers, PhD

Funding Agency: VA RR&D Total Approved Funding: $383,800

Timeframe: 10/01/06 – 09/30/09

Objectives: The 2004 VA Annual Benefits Report indicates that tinnitus is the third most common individual service-connected disability. As of September 30, 2005, there were 339,573 veterans who had been awarded a service connection for their tinnitus, with annual compensation amounting to over $418,000,000 (Office of Policy and Planning, VA Central Office). In addition to being a major expense for VHA, tinnitus is a health care problem that is inadequately addressed at most VA medical centers. Research at the NCRAR has resulted in a model of tinnitus clinical management that is designed for efficient implementation in VA audiology clinics. The objective of the proposed study is to establish the model program at a VA audiology clinic, and to evaluate its efficacy with veteran patients and its acceptability to audiologists and to hospital administration.

Research Plan: The study is based at the NCRAR, and a prototype tinnitus management program is being established at the James A. Haley Tampa VA Medical Center. Audiologists at the Tampa VAMC will be trained to conduct all phases of progressive intervention for tinnitus. Following training, the program will be implemented with veteran patients. Evaluation of the program's efficacy will involve outcome measures with the veteran patients, and assessment by audiologists and hospital administration.

Methods: During the first year of the study, a comprehensive web-based tinnitus training program for audiologists will be developed. Following development, audiologists at the Tampa VAMC will complete the training program as preparation to conduct each of five levels of intervention: screening, group educational counseling, tinnitus intake assessment, ongoing treatment, and extended treatment. In addition, a patient tinnitus-information booklet will be developed, using principles of low health literacy. The management program will be ready for clinical implementation by the end of the first year. During years 2 and 3, veteran patients who complain of tinnitus will be invited to participate in the program. Outcomes will be evaluated separately for clinicians, administrative staff, and patients. Clinicians will be surveyed to determine their level of satisfaction with the program. Administrative staff will be surveyed to determine if the program meets the needs and objectives of the medical center. Patients will be evaluated pre- and post-treatment to determine if participation in the program reduces their perceived tinnitus handicap.

Findings to date: The study is in its initial phase. There are therefore no findings to report.

Title: Frequency tuning and word recognition speed in older adults

Principal Investigator: Dawn Konrad-Martin, PhD

Mentors: Marjorie Leek, PhD; Stephen Fausti, PhD; Douglas Keefe, PhD

Funding Agency: VA RR&D Total Approved Funding: $388,403

Timeframe: 07/01/06 – 06/30/09

Objectives: Diminished frequency tuning caused by hearing loss can reduce spectral contrasts within the cochlear excitation pattern evoked by speech, even for hearing-impaired listeners fitted appropriately with hearing aids. We hypothesize that such distortions in the speech signal place greater demands on the cognitive resources of older adults when compared to young adults, reducing speech processing accuracy and speed. Objectives are to determine: 1) whether physiological estimates of frequency tuning based on response delays of tone-burst-evoked OAEs predict psychophysical tuning measures in young and elderly subjects; and 2) the extent that age and actual or simulated losses in sensitivity and frequency tuning alters the accuracy, speed and confidence with which listener's are able to identify time-gated words.

Research Plan: To address these objectives, groups of older and young adults with normal or impaired hearing will serve as subjects. Experiments assess listener's performance on a time-gated word recognition task, in which word recognition is evaluated as a function of the portion of the word presented. Performance on this task is thought to be related to how well an individual can follow rapid ongoing speech. Reduced speech spectral contrasts related to abnormal frequency tuning in subjects with hearing loss are examined for older- compared to young adults. Cochlear frequency tuning is estimated using OAE and psychophysical measurements performed in the same subjects.

Methods: Four groups of 20 individuals will serve as subjects (80 total subjects): 1) normal-hearing older subjects; 2) hearing-impaired older subjects; 3) normal-hearing young adult subjects; and 4) hearing-impaired young adult subjects. Older subjects are > 63 years with normal hearing or cochlear hearing loss (high frequency pure-tone-average [HFPTA] = 30-50 dB HL). Young subjects will be 18 to 35 years old with normal hearing or with cochlear hearing loss (HFPTA = 30-50 dB HL). Procedures include pure-tone audiometric assessment of conventional and ultra-high frequencies, physiological assessment (tympanometry and OAEs), psychophysical assessment (growth of masking), and real-time word recognition assessment (time-gated speech test). A battery of tests screens for depression and attention disorders and evaluate cognitive function.

Progress to date: Pilot data have been analyzed data to determine durations and frequencies needed to produce OAEs from brief stimuli that have amplitudes similar to that obtained using a continuous tone. We have implemented an energy-based method for calibrating the stimuli has been implemented which should improve estimates of the stimulus SPL reaching the eardrum. Programming has been performed to improve the post processing necessary to extract the emission, measure its peak amplitude and latency, and graph the results. Programming of the psychoacoustic and time-gated speech tests is underway. We have enrolled 13 subjects to date.

Title: Individualized objective measures for the early detection of ototoxicity

Principal Investigator: Stephen Fausti, PhD

Co-Principal Investigator: Curtin Mitchell, PhD

Funding Agency: VA RR&D Total Approved Funding: $322,200

Timeframe: 04/01/06 – 03/31/09

Objectives: There are over 200 medications that can adversely affect hearing. Therapeutic treatment with ototoxic drugs, particularly the aminoglycoside antibiotics and the chemotherapeutic agent cisplatin, can produce cochlear damage. Patients receiving these ototoxic drugs are at risk for incurring irreversible hearing loss that can adversely affect communication abilities. There is a clear need for a time-efficient, objective testing protocol to provide early detection of ototoxic-induced hearing impairment in patients who are unable to respond reliably to behavioral auditory tests.

This proposal will investigate and establish objective testing protocols suitable for clinical evaluation of all patients receiving ototoxic drugs. The effectiveness of individualized narrow-band auditory brainstem response (ABR) and fine resolution distortion product otoacoustic emission (DPOAE) will be evaluated relative to pure tone behavioral thresholds, the "gold" standard for early detection of ototoxicity. In order to develop an objective, clinically useful monitoring tool for early detection of ototoxic processes, the following objectives will be addressed: 1) to determine the extent to which individualized narrow-band ABRs and fine resolution DPOAEs provide early identification of hearing sensitivity changes in patients receiving ototoxic drugs. This will be accomplished by comparing changes in narrow-band ABRs and fine resolution DPOAEs to changes identified in behavioral pure-tone thresholds; 2) to determine which of the two individualized objective methods, narrow-band ABRs or fine resolution DPOAEs, provide the earliest evidence of change in relation to behavioral test results. The time of change occurring for the ABR and DPOAE methods will be compared to the time of change for the behavioral tests; and 3) to determine if the most effective individualized objective measure for early detection of ototoxicity established in the research laboratory is as reliable and sensitive on the hospital ward.

Methods: Individualized narrow-band ABR and fine resolution DPOAE data will be collected in conjunction with $1/6^{th}$ octave behavioral data in a large sample of patients who are at risk for developing ototoxicity. Equipment has been modified to maximize effective testing methods. During drug treatment, individualized narrow-band ABR and fine resolution DPOAE objective testing protocols will be used to assess hearing function within each patient's individualized sensitive range for ototoxicity. Behavioral threshold test results will be compared with narrow-band ABR and fine resolution DPOAE measures of hearing function. A comparison will be made between the changes in hearing sensitivity measured behaviorally with the changes in hearing function estimated by the fine resolution DPOAEs and the narrow-band ABRs. These comparisons will be made from results obtained in the laboratory and then the most effective measure will be tested at bedside with a portable unit.

Findings to date: The study is in its initial phase. There are therefore no findings to report.

Title: PVAMC educational initiative

Principal Investigator: Gabrielle Saunders, PhD

Funding Agency: PVAMC Education Division Total Approved Funding: $15,500

Timeframe: 6 months from start date, awaiting funding distribution

Objective: The long term goal of this initiative is to increase the knowledge held by medical staff regarding communication with individuals with hearing impairment, and thereby to alter their attitudes and behaviors towards such individuals. The short term goals are to: a) Develop two online courses. The first will provide medical staff with information that will increase their confidence and knowledge about communication with veterans that have hearing impairment. The second will provide in depth information about specific ways in which clinic and ward acoustics can be improved in order to enhance communication with all veterans, but especially those with hearing impairment. b) Provide follow-up assistance from NCRAR staff members if participants want additional information and/or advice about specific issues, such as the acoustics in a particular clinic or ward, or communication under unusual circumstances. The specific measurable outcomes will be: i) number of individuals completing the online classes; ii) scores obtained on the quizzes; iii) retention of information 3-months after completing the online classes; and iv) the number of changes implemented to the clinic or ward environment 6-months after the courses are posted on the VAMC education website. Further details about these measurable outcomes are provided below.

Educational Plan: The NCRAR will develop a web-based educational program for PVAMC medical staff that will: a) provide the information necessary for staff to become more confident and skilled at providing care for hearing impaired patients; and b) provide recommendations for improving the listening environment in clinics and wards around the hospital. The web-based classes will be developed using multi-media technology in order that the programs are not only interesting and captivating, but that they also provide the user with simulations of hearing loss which will demonstrate to participants some of the communication difficulties encountered by individuals with hearing impairment. These online classes will increase the efficacy and efficiency of the PVAMC staff by better enabling them to communicate with individuals with hearing impairment**.**

Methods: The program will consist of two online classes that will be developed. In addition to the classes, NCRAR staff members will be available to provide specific information and follow-up to individuals who request additional input after having completed both online courses. Individuals completing classes will be asked to provide email addresses or internal mail addresses at the start of the class if willing to do so, in order that they can be re-contacted later. Various components of learning including *reaction* to the programs, *learning* from the programs, *transfer* to other behaviors and perceived *value* of the programs will be assessed in both the short term and the long term.

Progress to date: The study has not yet begun therefore there are no findings to date.

Title: Randomized trial of a brief patient-centered aural rehabilitation model

Principal Investigator: Mitchel Turbin, PhD

Co-Principal Investigator: Harvey Abrams, PhD

Funding Agency: VA RR&D Total Approved Funding: $314,400

Timeframe: 04/01/06 – 03/31/09

Objectives: This study compares outcomes of standard VA audiology clinic hearing aid dispensing practices (control treatment) to standard care plus a two hour group Aural Rehabilitation session (experimental treatment). Hearing aids are the primary rehabilitation treatment for alleviating the negative effects of hearing loss, which disrupts communication and consequently impedes normal social, emotional and vocational relations. However, hearing aids cannot fully restore the complex sense of human hearing; hence some residual communication difficulties remain even with the use of advanced hearing aids. Group Aural Rehabilitation (AR) provides a forum for audiologists to teach patients a variety of skills for compensating for those residual communication difficulties. Realities of the typical VA and private sector audiology clinic have resulted in traditional multi-session AR group formats being truncated into a single session format in most cases where AR is offered. This study carefully distills ingredients from behavioral medicine, psychology and audiology to produce an optimized AR for our experimental treatment.

Research Plan: Three hundred and ten veterans total will be recruited from two study sites: the Portland VA and Bay Pines VA Medical Center audiology clinics. Patients will be enrolled into the study after they have been evaluated for hearing aids but before the hearing aids are fitted. Questionnaires will be administered before hearing aid fitting, eight weeks after fitting, and six months after fitting. Participants will be randomly assigned to either AR or control groups after their baseline assessments.

Methods: All participants in the study will take the same four questionnaires. The primary instrument measures a range of adjustment behaviors and attitudes. Other measures assess personality variables, coping styles and communication improvement goals. The AR groups "The Living Well with Hearing Loss Workshop" will be single two hour sessions facilitated by experienced audiologists who are trained in the patient-centered model of medical care, a communication based approach that emphasizes patients' self management of health and a partnership between patients and providers.

Findings to date: Patient accrual has not as yet begun, but is soon to be initiated.

Ongoing VA Funded (n = 15; total funding received = $12,088,239)

Title: A biological interface for rehabilitation with a cochlear implant

Principal Investigators: Allen Ryan, PhD

Co-Principal Investigator: Stephen Fausti, PhD

Funding Agency: VA RR&D Total Approved Funding: $660,000

Timeframe: 04/01/05 – 03/31/08

Objectives: The cochlear implant employs electrical stimulation to activate auditory neurons in patients that have lost their hearing due to the death of inner ear sensory cells. This device is now widely used to treat the deaf, and is increasingly used for patients with small amounts of residual hearing. It provides substantial benefit for the profoundly deaf, but the performance of even the most successful patients is far lower than that achieved by normal hearing listeners. In addition, there have been recent concerns regarding infection that can lead to meningitis. The proposed research program is designed to improve the cochlear implant by combining device engineering and biological approaches. Performance will be enhanced by decreasing the distance between the electrodes and cochlear neurons, so that more channels of information can be delivered, and by increasing the survival of cochlear neurons. Improving the seal around the base of the implant, to exclude infection, will enhance safety. These goals will be achieved by producing a biological interface between the implant and the tissues of the inner ear.

The general principles studied in this program will also be applicable to other health problems of veterans. Improved interfaces between electrode arrays and neurons could also be applied to veterans with visual deficits and in spinal cord injury.

Research Plan: The first phase of this program is to identify factors to which the tissues of the cochlea will respond with growth toward, and adherence too, implant materials. Experiments are proposed to explore the guidance of nerve fibers from cochlear neurons toward the implant using soluble factors, extracellular matrix molecules and repulsive signaling molecules. Additional studies will evaluate the growth of neurites through three-dimensional substrates that can link a cochlear implant to the region of the spiral ganglion. Further studies will develop artificial sensory epithelia in order to maintain cochlear nerve fibers at the surface of the implant.

Methods: Identification of factors critical for the growth of spiral ganglion neurites are first evaluated in vitro. Explants of adult spiral ganglion are exposed to soluble and surface-bound factors that can serve as growth substrates or provide guidance for nerve fibers. Factors that prove successful in vitro will then be tested in vivo by introducing them into the adult cochlea.

Findings to date: We have determined that adult SG neurons respond to BDNF, NT-3 and GDNF, although with reduced magnitude of response when compared to younger neurons. Unlike some ages of developing neurites, adult neurites respond better to BDNF. We have evaluated the response of adult SG neurites to patterned substrates, and found that they can be channeled along a pattern of extracellular matrix molecule stripes. Moreover, they prefer stripes of laminin over stripes of fibronectin. We have also tested the responses of SG neurites to gradients of NT-3, BDNF and netrin, as well as to a gradient between NT-3 and BDNF. Neurites will clearly follow a steep gradient of NT-3 produced in a microfluidic device, but not of BDNF. In competition, not surprisingly, they prefer NT-3. However, more shallow gradients of NT-3 or BDNF produced by osmotic minipumps do not produce directional responses.

Title: Auditory function in patients with and without multiple sclerosis

Principal Investigator: David Lilly, PhD

Co-Principal Investigators: Stephen Fausti, PhD; Dennis Bourdette, MD

Funding Agency: VA RR&D Total Approved Funding: $596,800

Timeframe: 04/01/02 – 03/31/06

Objectives: The nature of auditory dysfunction in patients with multiple sclerosis (MS) has not been identified clearly. It has been reported that 40% to 60% of MS patients with normal hearing sensitivity have difficulty hearing in everyday listening conditions. These reports are consistent with observations from clinicians that up to half of their patients have difficulty understanding speech, especially in a background of noise. These perceptual difficulties have been attributed to a variety of things, such as memory problems, fatigue or dementia. We hypothesized, however, that they may be due in part to auditory-processing deficits caused by focal loss or destruction of myelin sheath (demyelination) within the auditory nervous system. Our primary goal, then, was to characterize auditory function and cognitive function in patients with Multiple Sclerosis (MS).

Research Plan: We developed the requisite instrumentation and test materials to evaluate auditory function and neuropsychologic function in 150 patients with MS and in a group of 150 control subjects who do not have MS, but who were matched with respect to age, sex, and audiometric configuration to the MS group. Experimental subjects were recruited by selecting patients with a verified diagnosis of MS from the registry of patients established by the Oregon Health & Science University, and the Portland VA Medical Center.

Methods: We used selected audiometric, acoustic, psychoacoustic, neurophysiologic and cognitive procedures on both groups of subjects. All data acquisition was completed by 31 March 2006.

Findings to date: During the course of completing this study we conducted approximately 1000 test sessions involving MS patients, control subjects, and pilot subjects. Five or six test sessions were completed on each MS patient and on his or her matched control. In general, we observed significant differences between the two groups on: 1) speech intelligibility in noise; 2) masking-level differences for a 500 Hz pure-tone; 3) the Staggered-Spondaic Word test; and 4) on the Dichotic Listening test. Evoked-potential data and otoacoustic emission data still are being reduced. Preliminary pilot data also have been obtained on a smaller subset of subjects using behavioral tests that are designed to evaluate central auditory function (CAP tests). These CAP tests have been incorporated into a proposal that has been submitted as a competitive renewal application for our work on patients with MS. The proposal was approved for funding in 2006 and we are awaiting the determination of a start date and award of funding.

Analysis of our pilot studies suggest differences in test performance between patients with MS and their controls on the following tests: 1) the Gaps-in-Noise Test (at 5-ms and 6-ms gap durations); 2) the Dichotic Digits Test (for the left ear); 3) the Auditory-Figure Ground subtest of the SCAN-A; 4) the Competing Words subtest of the SCAN-A; and 5) the Competing Sentences subtest of the SCAN-A. These results provide support for the existence of CAP deficits in patients with MS.

Data analysis currently is underway along with the preparation of manuscripts for publication.

Title: Development of clinical instrumentation for tinnitus measurement

Principal Investigator: James Henry, PhD

Funding Agency: VA RR&D Total Approved Funding: $554,129

Timeframe: 10/01/03 – 12/30/06

Objectives: Although tinnitus is a major problem for veterans and for the VA, most VAMCs do not have systematic clinical care available for their veterans suffering from tinnitus. Through continuous RR&D funding since 1995, we have developed a sophisticated computerized system for tinnitus quantification. The objective of the present study is to further develop the system to make it available for widespread application at VA audiology clinics.

Research Plan: To achieve the end goal, the tinnitus test system will be re-engineered and re-developed as a clinical piece of equipment. Following redevelopment and beta testing: reliability testing will be performed; a technique to test for "tinnitus malingering" will be developed; and the system will be evaluated in four VA audiology clinics.

Methods: Project 1 will consist mainly of technical development of the new automated system. System refinement will continue to the end of the study period. For Project 2, human testing will be conducted to evaluate test-retest reliability of responses to the various tests that the system will perform. Specific testing will be done to develop a tinnitus malingering test. With such a test, veterans with true tinnitus are expected to provide a characteristic profile of responses, while those feigning tinnitus would reveal a different profile. Two groups of veterans will be recruited from the Portland VAMC to complete this project: those with chronic tinnitus and those without tinnitus. For Project 3, the new system will be installed at four VAMC audiology clinics: Portland; Bay Pines, FL; San Diego, CA; and Biloxi, MS. The automated technique will be used to provide routine tinnitus assessment of veteran patients with the primary complaint of tinnitus. Project 3 is important to demonstrate that the system can be utilized in the clinical setting, and to obtain feedback from VA audiologists regarding the system's performance.

Findings to date: The study was recently completed, and is in the data analysis phase.

Title: Disability Supplement Award

Principal Investigator: Mitchel Turbin, PhD

Mentors: Marjorie Leek, PhD; Stephen Fausti, PhD; James Henry, PhD; Ken James, PhD

Funding Agency: VA RR&D Total Approved Funding: $225,404

Timeframe: 11/01/05 – 10/31/08

Objectives: This award is intended to provide supplemental salary support for Dr. Turbin as he continues to evolve into an independent research scientist while the NCRAR provides a nurturing and supportive mentoring, training and research career development environment. The NCRAR also provides Dr. Turbin with research administration and technical support, rehabilitation research facilities and access to scientific literature and clinician researchers in many complementary disciplines.

Research Career Development Plan: Dr. Turbin is serving as Principal Investigator for the RR&D service entitled, "Randomized Trial of a Brief Patient-Centered Aural Rehabilitation Model" in June 2005. The study proposed a randomized dual site parallel investigation comparing typical VA audiology (hearing aid rehabilitation alone) with typical VA audiology plus a one-session group Aural Rehabilitation intervention. In addition, he will be engaged in preparing articles for publication in peer reviewed journals during the first year of this award. Contacts have been made with editors who have encouraged these submissions: "The Emerging Epidemic of Hearing Loss: Roles for Psychologists," *Professional Psychology: Practice and Research* (in preparation) and "Biopsychosocial Audiology: 'Patient-centered' May Not Be What You Think," *Journal of the American Academy of Audiology* (in preparation). Dr. Turbin will also prepare posters and lectures for presentation at national or regional scientific conferences and clinical forums. Primarily, Dr. Turbin will prepare and submit proposals for funding by VA and non-VA agencies, including RR&D and NIH, working in collaboration with senior NCRAR and other colleagues.

Methods: Dr. Turbin will be in regular consultation with Drs. Leek, Fausti, Henry and James, and other senior NCRAR colleagues. He will commence the writing of proposals for merit review submissions in the second year of this RR&D Disability Supplement Award.

Findings to date: Dr. Turbin obtained approval of funding for his first VA merit review project in 2006, and is actively pursuing additional peer reviewed funding.

Title: Effects of age and noise on peripheral auditory processing in relation to speech recognition

Principal Investigator: Dawn Konrad-Martin, PhD

Mentors: Stephen Fausti, PhD; Nancy Vaughan, PhD; Tianying Ren, MD; Douglas Keefe, PhD

Funding Agency: VA RR&D Total Approved Funding: $294,267

Timeframe: 07/01/03 – 06/30/06

Objective: The goal of this Research Career Development (RCD) grant was to provide training to allow this new investigator to secure independent funding for a program of research aimed at understanding the influence of aging and noise over-exposure on peripheral auditory system function in humans. Research aims included (1) determining effects of age and noise exposure on outer-hair cell-assisted basilar membrane function and inner hair cell/auditory nerve transduction; and (2) determining whether speech recognition in noise is correlated with pre-neural (basilar membrane) or auditory nerve responses in young and elderly individuals with and without hearing loss.

Research Plan: The plan was to generate pilot data to pursue independent funding. To address Aim 1, the plan involved testing cochlear (otoacoustic emission, OAE) and neural (compound action potential, CAP) responses to make inferences about specific aspects of peripheral auditory system function which may contribute to age-related changes in the ability to understand speech. To address Aim 2, the plan involved testing subject's ability to understand speech in noise. To address Aim 3, correlations among these three measures were to be tested.

Methods: Elderly subjects were 63 to 83 years old with normal hearing through 4 kHz and no more than a mild loss at 6 and 8 kHz. Young subjects were 18 to 35 years old with normal hearing through 8 kHz. Procedures included standard pure-tone audiometric assessment, extended-high frequency threshold testing and OAE measurements. Additionally, in a few pilot subjects, CAP measurements were made. Since the optimal OAE stimulus paradigm for pip-evoked OAEs was not clear *a priori*, results of three tone-pip evoked OAE stimulus paradigms were compared, tone-pip pairs separated in frequency by 3% or 6%, and continuous tones paired with tone pips. OAE correlates of growth functions and tuning were generated from the OAE data. Auditory nerve correlates of response growth were assessed using CAP responses.

Findings to date: Major findings involve experiments used to test the prediction that OAE latencies and cochlear tuning are linked. OAE amplitudes and latencies were measured as a function of frequency and level in 22 young-normal and elderly-normal ears. There was good accord between latencies obtained in young adults in the present study and those obtained for similar frequencies and levels elicited using continuous tones (Shera and Guinan, 2003), providing evidence that a non-invasive OAE measure of latency can be used to estimate cochlear tuning. Frequency and level-dependent shifts in tone-pip-evoked OAE latency were observed in young and old ears. Latencies in older adults were similar or shorter compared to young adults at equal SPLs. Amplitudes were lower and thresholds higher for OAEs elicited by all tone-pip combinations compared with continuous tones. Pilot CAP data was generated for proof of concept to include in grant submissions. Two successful grant submissions have resulted from this research this year: VA ARCD #C4447K and NIH R03 #DC008203-01. These two grants extend and refine current work by exploring measures of speech perception and CAP responses in addition to OAE responses. In addition, one manuscript was published (Fausti et al., 2006) and one presentation was given based on this research.

Title: Hearing rehabilitation from the perspective of the significant other

Principal Investigator: M. Samantha Lewis, PhD

Funding Agency: VA RR&D Total Approved Funding: $336,900

Timeframe: 07/01/05 – 06/30/08

Objectives: The presence of a hearing impairment can negatively impact the significant other (SO), as well as the individual with hearing loss. Although hearing aids improve communicative performance, they do not entirely remedy hearing dysfunction. Factors such as patient pre-use expectations have been shown to impact post-use satisfaction. It is thus logical to assume then that the SO's pre-use expectations and perhaps also post-use satisfaction may impact hearing aid outcome. At this time, however, these factors have yet to be examined. The purpose of this investigation is to put in place the tools for examining the pre-use expectations of, and the post-use satisfaction with, hearing aids from the SO's perspective by developing assessment questionnaires. To accomplish this task, two routinely used and standardized questionnaires, the Expected Consequences of Hearing aid Ownership (ECHO) and the Satisfaction with Amplification in Daily Living (SADL) will be used as a starting point and adapted accordingly. Pilot questionnaires will be developed based upon these questionnaires and from information obtained during interviews with non hearing-impaired SOs of individuals with mild to moderately-severe sensorineural hearing loss. Analyses of factor structure and reliability will be assessed for each questionnaire. These questionnaires will allow hearing professionals to assess the impact that hearing aids have on the individual with hearing loss, as well as his/her SO. With this information, they will be better able to tailor their counseling to the needs of the family unit and better understand the relationship between the perceptions of the SO and user outcome.

Research Plan: Two questionnaires will be developed for clinical use with the SO. The first questionnaire will query the SO regarding his/her pre-use expectations about hearing aid outcome. The second questionnaire will query the post-use satisfaction experienced by the SO with amplification. The questionnaires will be developed modeling the format of the ECHO and the SADL and adapted to the SO's perspective. Additional questions will be developed and current questions modified using data collected during interviews with non hearing-impaired SOs of individuals with hearing impairment and their hearing-impaired partners. Data obtained from these interviews will be coded into common themes and used for questionnaire development. The psychometric properties of these questionnaires will be evaluated.

Methods: In order to create two questionnaires for clinical use with the SO, this project will be completed in two phases. In the first phase, spousal pairs in which the individual with hearing impairment is considering getting hearing aids will be interviewed in order to develop pilot questionnaires. Once these questionnaires are developed, non-impaired SOs will complete both sets of questionnaires. The pre-use expectation questionnaire will be completed prior to the partner with hearing impairment receiving a hearing aid and the post-use questionnaire will be completed six weeks after the hearing aid is fit. Analyses of the psychometric properties of these questionnaires will be conducted using factor analysis. The test-retest reliability of the questionnaires will be assessed.

Findings to date: Results thus far suggest that conversation is easier, TV/radio is softer, life is less noisy, and that there is less repeating and less arguments with the use of hearing aids.

Title: Investigation of individualized OAE techniques for early detection of ototoxicity

Principal Investigator: Stephen Fausti, PhD

Participating Investigator: Dawn Konrad-Martin, PhD

Funding Agency: VA RR&D Total Approved Funding: $746,900

Timeframe: 10/01/03 – 12/31/06

Objectives: The long-term goal of this research is to provide early detection and prevention of ototoxic hearing loss in veterans. The objective of this study is to determine the most reliable, sensitive and efficient *objective* technique for early detection of ototoxicity using otoacoustic emission (OAE) testing.

Research Plan: Distortion-product OAE (DPOAE) and stimulus-frequency OAE (SFOAE) test performance for detecting ototoxic hearing change is compared in this study. Individualized OAE data are collected in conjunction with behavioral threshold data in patients receiving ototoxic drugs at four study sites. Experimental subjects are inpatients and outpatients receiving selected ototoxic drugs. Control subjects are healthy individuals, and hospitalized patients not receiving ototoxic drugs.

Methods: DPOAEs and SFOAEs were collected in the form of response growth functions, in which test frequency (f_2) was held constant and L_2 varied in 5-dB steps. For control subjects, f_2 varied in 1/3-octave intervals from 1.0 kHz to 10.0 kHz (the equipment limits). For drug-exposed subjects, f_2 varied from 1.0 kHz to the highest f_2 yielding a valid response. Several OAE metrics were generated which express in a single value, multiple stimulus level and amplitude combinations. Simple logistic regression will be used to asses the association between each OAE variable and categorical variables based on the results of behavioral hearing tests (ototoxic hearing change vs. no change). Any OAE variable whose univariable test has a p-value ≤ 0.25 will be a candidate for a multivariate model along with variables of known biological importance. Within the multivariable model, each independent variable will be verified and only variables with significance at a .05 level will be retained. Interactions between the variables remaining in the multivariate model will be investigated and if significant at a .10 level will be included. The discriminative ability of the final multivariate model will be assessed using clinical decision theory in order to determine the efficacy of OAEs as an ototoxicity-monitoring tool.

Findings to date: Data were obtained in 42 healthy control subjects during two visits within one month. An additional 99 patients were enrolled as subjects. Patients were tested before, during and after drug administration, yielding on average 4.5 tests per subject (range 1-13 tests). Fewer OAE responses were obtained at low L_2 and at the lowest and highest f_2's tested, consistent with results in previous studies. The median highest f_2 able to elicit a valid response was 8 kHz and 6.35 kHz for DPOAEs and SFOAEs, respectively. However, these differences were not significant. We have created a database of variables including patient demographics, medical and hearing history, audiometric results (otoscopy, tympanometry, and behavioral thresholds), tinnitus results, drug dosing regimen, and DPOAEs and SFOAEs. OAE data has been verified for accuracy and transformed into several metrics which will be used to determine whether OAEs are likely to be reliable measures of the presence and magnitude of ototoxic changes in cochlear function.

Title: Multi-site randomized clinical study of tinnitus treatment methods

Principal Investigators: James Henry, PhD

Co-Principal Investigator: Martin Schechter, PhD

Funding Agency: VA RR&D Total Approved Funding: $682,729

Timeframe: 01/01/04 – 12/30/06

Objectives: Although tinnitus is especially problematic for veterans, the DVA has no established protocol for tinnitus rehabilitation. We recently completed a randomized clinical trial to evaluate the efficacy of tinnitus treatment for veterans. Tinnitus Masking (TM) and Tinnitus Retraining Therapy (TRT) were both shown to be effective for the majority of veterans treated with these methods by "expert" tinnitus clinicians. The objective of the present study is to determine if the same level of treatment efficacy observed in the previous study can be obtained by "typical" VA audiologists in their clinical environment. In addition, a third group has been added, called Audiologic Tinnitus Management (ATM) that will serve as a control group for nonspecific effects of treatment using a standardized protocol of hearing aids and education.

Research Plan: Veterans with clinically significant tinnitus were recruited to receive treatment with TM, TRT, or ATM in Audiology Clinics at the Bay Pines, Portland, San Diego, and Seattle VAMCs. There are three Treatment Audiologists at each of the sites, one for each of the three treatment methods. Each method uses a variation of "sound therapy" and of educational counseling. Sound therapy involves the use of wearable ear-level devices, including sound generators ("maskers"), hearing aids, or combination devices (hearing aid and masker combined). Only the ATM group is restricted to the use of hearing aids only (note: ATM subjects who do not require hearing aids are the only subjects in this study who do not receive ear-level devices). TRT uses a structured counseling protocol that teaches concepts that are unique to TRT. The TM protocol has been created to match the TRT counseling with respect to comparable formatting and length of counseling sessions, but containing information specific to the concepts of TM. The ATM counseling is similarly matched in format and length, but the information is more generic. Assessment of outcomes will utilize questionnaires that are administered at intervals before, during, and after the 18 months of treatment.

Methods: Potential participants at all sites were telephone-screened by the Project Audiologist in Portland to determine if the tinnitus is a problem sufficient to warrant 18 mo. of treatment. Veterans who passed the screening were scheduled to meet with the Research Coordinator (RC) at the respective study site. At this first visit, veterans completed informed consent and questionnaires, and were then informed of their group placement. Per a randomization schedule, they were placed into one of the three treatment groups, or into the 6-mo. waiting list group (with treatment starting 6 mo. later). At the initial evaluation with the respective Treatment Audiologist, a tinnitus verbal interview was administered, and hearing and tinnitus testing were performed. Custom ear-level devices were then ordered. Veterans returned 3-4 weeks later for device fitting and to receive the counseling/education that initiates treatment. Subjects return for follow-up treatment at 3, 6, 12 and 18 months. At the follow-up appointments, the RC collects and checks the questionnaires, and the Treatment Audiologist administers the follow-up verbal interview and repeats the counseling protocol. One year following treatment, the Project Audiologist will mail out written questionnaires that will be returned by mail, and will telephone the subjects to repeat the follow-up verbal interview.

Findings to date: The study has been completed and is in the data analysis phase.

Title: Ototoxicity Identification (OtoID) Device

Principal Investigator: Stephen Fausti, PhD

Co-Investigators: Roger Ellingson, MSCSE; Wendy Helt, MA

Funding Agency: VA RR&D Total Approved Funding: $488,300

Timeframe: 07/01/04 – 12/31/07

Objective: The primary objective of this rehabilitation engineering proposal is to develop our prototype unit into a user-friendly, portable, computer-automated audiometer-like device that performs individualized ototoxicity early monitoring using the evidence-based 1/6th octave sensitive range for ototoxicity (SRO) methodology.

Research Plan: The proposed project seeks to develop the prototype unit into a second-generation OtoID device. Key elements to successful completion of the OtoID project include: 1) hardware improvements to the prototype circuitry; 2) the development of custom-programmable SRO software applications to perform time-efficient and user-friendly ototoxicity early identification; 3) the development of PC-based data collection and reporting applications; and 4) field testing of the OtoID device in sound attenuation booths and hospital ward rooms at the Portland VAMC, in hospital ward rooms at distant site VAMCs, and in patients' homes.

Methods: The work proposed is divided into three phases: 1) prototype device upgrading; 2) software application development; and 3) data collection and reporting system. Phase I is focused on upgrading the hardware of the prototype device with support for computer-controlled output range switching, ambient noise measurement, performance verification support, non-volatile storage, and telephone communication. Phase II is focused on developing the OtoID automated software applications for ototoxicity testing. This work will commence once the engineer has completed development of the automated output ranging circuitry. Also, the engineer must complete the support for ambient noise measurement, performance verification and non-volatile storage so that extensive testing can be completed prior to the end of Quarter 6. In Phase III, we will concentrate on implementing the telemedicine-based data collection, reporting and sharing system, as well as extensive system reliability and sensitivity verification of onsite, remote site, and in-home test locations.

Findings to date: The current prototype consists of: 1) a handheld computer; 2) a prototype custom module; and 3) Sennheiser HDA200 headphones. The unit operates using a custom application that has been programmed to: 1) generate pulsed, stereo, pure-tone stimuli; 2) provide "pen-enabled, touch-pad" operated control of frequency selection, calibrated sound level selection, and muting functions; and 3) support on-screen recording and saving of hearing thresholds. The project team is wrapping up Phase II, which included performance and reliability testing on human subjects in a controlled audiometric environment. Comparison testing has been performed with previously used clinically based audiometric instrumentation. Now that the Phase II data collection and comparison studies have been completed, the device is being upgraded to support ambient noise measurement which will allow testing in the uncontrolled audiometric environments of hospital wards and patient homes in Phase III of the project. A software application is being written to support the automated patient guided testing that will be used in Phase III.

Milestones: The VA has asserted its ownership rights to this invention and the rehabilitation research project team has initiated preliminary discussions with a private industry company that may lead to a Cooperative Research and Development Agreement to take this device into production and marketing.

Title: Senior Research Career Scientist Award

Principal Investigator: Marjorie Leek, PhD

Funding Agency: VA RR&D Total Approved Funding: $1,190,210

Timeline: 10/01/05 – 09/31/12

Objectives: The goal of this award is to provide salary support for a senior clinical scientist who will contribute to the research program of the VA and the NCRAR through research and leadership activities. The holder of this award provides mentoring and scientific training to junior VA scientists, maintains an active research program relevant to the mission of the organization and to veterans' health care, serves as a resource to the research community, collaborates with other scientists and clinicians, and serves on VA research and other committees.

Research Plan: Research will be carried out to determine the functional mechanisms of hearing loss and their involvement in deficits in speech understanding by hearing impaired veterans. This work is currently supported by an NIH R01 grant that has been funded for nearly twenty years. Further research funding has been awarded from the Oticon Foundation for a collaborative project with scientists at Walter Reed Army Medical Center to determine the benefit of providing individualized auditory computer models to characterize a patient's impaired hearing, with the ultimate goal of developing improved signal processing in hearing aids. Additional research proposals are under development. Active mentoring is underway for two young scientists who have been awarded VA RR&D Associate Investigator Awards and for another staff scientist at the NCRAR who currently holds a Research Career Development Award. Mentoring is also provided for a post doctoral research associate.

Methods: The implementation of the SRCS award involves preparing grant applications and designing research; developing laboratory resources and hiring and mentoring post doctoral research associates; providing service to national and local professional organizations including reviews of articles and grant proposals; and publishing research findings in national journals and at national meetings.

Progress to date: To date, studies are underway supported by the NIH grant and the Oticon Foundation grant. Four new proposals were submitted during the past year, and the SRCS was actively involved in preparation of the Center grant renewal application for the NCRAR. Collaborations with scientists at Walter Reed Army Medical Center, the University of Maryland, and the University of Washington have been maintained or newly established. Research audiologists and assistants have been hired to work in the laboratory and data collection and ongoing analyses are in progress.

Title: The effects of diabetes on processing of verbal communication

Principal Investigator: Stephen Fausti, PhD

Co-Investigators: Donald Austin, MD, MPH; Susan Griest, MPH

Funding Agency: VA RR&D Total Approved Funding: $768,000

Timeframe: 07/01/04 – 06/30/08

Objectives: The primary objective of this study is to determine whether diabetes related cognitive deficits are associated with greater difficulty understanding speech in adverse listening conditions for diabetic than non-diabetic patients.

Research Plan: This is a follow-up study conducted by the VA National Center for Rehabilitative Auditory Research at the Portland VA Medical Center, in collaboration with Dept. of Public Health, Oregon Health Sciences University in Portland. The study is an observational two-group comparison study, designed to compare the diabetic and non-diabetic patients on a number of auditory and cognitive neural processing tasks and on two types of speech recognition tests.

Methods: Electrophysiologic, physiologic, and behavioral tests are conducted on two diagnostic groups of veterans – diabetic and non-diabetic. Electrophysiologic and physiologic tests will examine cochlear integrity (stimulus-frequency otoacoustic emissions), central brainstem conduction time (rate auditory brainstem studies), and speed of processing (cognitive P300 potentials). Behavioral tests will include clinical and experimental neuropsychological tests as well as speech recognition tests. Written questionnaires elicit data about the potential confounding variables such as coexisting medical conditions, noise exposure history, and health and disability status. Subjects also undergo special tests to detect and quantify peripheral neuropathy, and a small blood sample is drawn to check glycosylated hemoglobin (HbA1C test).

Findings to date: During the period January 1, 2006, through December 31, 2006, the number of patients tested increased by 62 (40 with diabetes and 22 without diabetes) with total test sessions for this period equaled 186. An additional 12 patients were excluded based on the results of audiometric screening criteria. All participants were recruited from lists of outpatients of the Portland VA Medical Center, Portland, OR. Testing protocols were refined and data quality procedures were incorporated into the routine procedures. No data have been analyzed to date but the collected data are undergoing data reduction in preparation for analysis.

Title: The impact of hearing aid directional microphones on sound localization

Principal Investigator: Gabrielle Saunders, PhD

Co-Investigator: M. Samantha Lewis, PhD

Funding Agency: VA RR&D Total Approved Funding: $484,800

Timeframe: 01/01/05 – 12/31/07

Objective: The purpose of this study is to investigate the impact hearing aid directional microphones have upon sound localization and speech intelligibility. The use of directional hearing aids represents a promising approach to the problem of speech in noise, but these instruments also impose constraints, such as reduced localization cues. It is important to evaluate both the advantages and limitations of directional hearing aids under realistic conditions of use. The issues to be addressed in the proposed research include an assessment of the magnitude of the improvement in intelligibility, the relative loss in localization ability and its practical consequences (if any) and other possible limitations that may be encountered in the everyday use of directional hearing aids.

Research Plan: This investigation will compare performance with directional microphones and omnidirectional microphones. Specifically, this investigation will: 1) document the impact of omnidirectional, cardioid and supercardioid microphone polar patterns upon sound localization; 2) evaluate the effect of these microphone polar patterns on speech intelligibility in noise; and 3) determine whether sound localization and speech intelligibility in noise changes differentially over the first few weeks of use for individuals wearing hearing aids with directional versus omnidirectional microphones.

Methods: Seventy subjects will undergo routine audiometric testing, an evaluation of sound localization for low, mid- and high-frequency signals and measurement of speech intelligibility in noise. All subjects will then be fit with a pair of in-the-ear hearing aids with selectable microphone polar patterns. They will undergo aided sound localization testing and speech intelligibility testing, with the microphone polar pattern in the omnidirectional, cardioid and supercardioid modes. Following testing, subjects will be randomly assigned to one of two groups (1) those who will wear the hearing aids in the omnidirectional mode for 24 weeks and (2) those who will wear the hearing aids in the cardioid mode for 24 weeks. Following this, subjects will return to the laboratory for sound localization and speech intelligibility in noise testing.

Findings to date: Hardware and software development is completed for measurement of hearing aid polar patterns and for speech intelligibility testing. The experiment has been set up in the NCRAR's new anechoic chamber and subject recruitment, enrollment and screening is underway.

Title: The Performance-Perceptual Test (PPT) as a counseling tool

Principal Investigator: Gabrielle Saunders, PhD

Co-Principal Investigator: David Lilly, PhD

Funding Agency: VA RR&D Total Approved Funding: $249,800

Timeframe: 07/01/05 – 06/30/07

Objectives: Hearing aid dissatisfaction continues to be disappointingly high, even though technology has improved dramatically over the last 10 years or so. Unfortunately, the results of most commonly used self-report measures cannot be directly compared with the results from performance measures since the modes of testing are very different. Thus, it is hard for clinicians to reconcile data from individuals reporting more handicap or less hearing aid satisfaction than would be expected from their performance. In this study, we aim to use a test known as the Performance-Perceptual Test (PPT) to determine whether simple counseling based upon discussion of PPT results can be used to better align perceived and measured ability to understand speech-in-noise and, more importantly, whether such counseling can decrease reported handicap and improve hearing aid satisfaction, regardless of its impact upon perceived hearing ability.

Research Plan: The study will be conducted over a two-year period. We will determine whether PPT-based counseling can decrease reported handicap and increase hearing aid satisfaction among individuals that underestimate their hearing ability and their hearing aid benefit. The following questions will be addressed: 1) Does a combination of the Performance SRTN and the PPDIS explain the variance in aided reported handicap to the same extent that it explains the variance in unaided reported handicap? 2) Can simple counseling based upon an individual's PPT scores better align an individual's perception of his/her hearing ability with his/her actual hearing ability? 3) Can this counseling successfully decrease unaided and/or aided reported handicap in individuals that underestimate their hearing ability and report excessive handicap for their degree of impairment? 4) Can PPT-based counseling increase satisfaction with hearing aids among hearing aid users that underestimate their hearing aid benefit?

Methods: Hearing aid users will complete the PPT for aided and unaided listening, along with standardized questionnaires measuring reported auditory disability, handicap and hearing aid satisfaction. Following this, subjects will be randomly assigned to one of two groups. Subjects in Group 1 will receive counseling from the experimenter in the form of an explanation and discussion of their PPT results. Subjects in Group 2 will also participate in a discussion with the experimenter, but it will not include an explanation of the PPDIS. Two weeks after enrollment in the study subjects will complete a second set of questionnaires. Ten weeks after study enrollment subjects will return to the laboratory to rerun the test battery. The impact of the counseling upon PPDIS values, reported handicap and hearing aid satisfaction and benefit will be compared across the two groups.

Findings to date: Fifty-three participants have been recruited into the study, of whom thirty-five have completed the protocol. Preliminary data have been published in Saunders GH, Forsline A. (2006) The Performance-Perceptual Test (PPT) and its application to hearing aid counseling. *The Hearing Review* 13(13), 18-25.

Title: Veterans Affairs National Center for Rehabilitative Auditory Research (NCRAR)

Principal Investigator & Director: Stephen Fausti, PhD

Co-Principal Investigator & Associate Director: Dennis Bourdette, MD

Funding Agency: VA RR&D Total Approved Funding: $4,150,000

Timeframe: 10/01/02 – 09/30/07

Objectives: Auditory disabilities affect veterans of all ages and represent the most prevalent individual service-connected disability among veterans receiving compensation from the Veterans Benefits Administration (VBA) in fiscal year (FY) 2005. More than 753,000 veterans had a service-connected auditory disability that required compensation from the VBA. In FY 2005, total compensation to veterans exceeded $1 billion for hearing loss and tinnitus disabilities, an increase of 168% over the preceding four years. Furthermore, an estimated one million additional veterans are service-connected for their hearing loss and tinnitus, but do not receive compensation. The high incidence of hearing disabilities among veterans creates a tremendous and growing demand for hearing healthcare services within the Department of Veterans Affairs (VA). Most importantly for our veteran population, hearing loss and tinnitus can have a life-long negative impact on communication and quality of life.

VA research, while targeting veterans, provides significant benefit to all Americans. The VA's support of auditory rehabilitation research is equally important for veterans receiving compensation, for the millions of veterans who have a non-compensable hearing loss, and for the nearly 35 million individuals in the United States who are affected by hearing loss. This communication disorder—the most common chronic health condition in all age groups—profoundly affects social, vocational, and psychological functions (Ruben, 2000). Moreover, the incidence of hearing loss increases dramatically with age: about 40-45% of people over age 65 years have some degree of hearing loss, with the number increasing to about 83% in individuals over 70 years of age (Cruickshanks et al., 1998). In the 30 years between 1990 and 2020, it is projected that the number of veterans over 85 years will have increased by 568%; while the median age of veterans is projected to increase from about 58 years today, to over 62 years by 2020. As the population ages, the problem of hearing impairment will place unprecedented demands on health care. The NCRAR is a comprehensive research organization dedicated to the discovery of effective solutions for veterans' auditory disabilities, and the translation of evidence-based research results into practice throughout the VA healthcare system and the nation.

Plan: The Center uses a multi-disciplinary approach that includes both basic and clinical research components to bring diverse perspectives and solutions to common auditory problems.

Methods: Our research strategy encompasses the progression from basic theoretical research to clinical care, including three major research areas: the *diagnosis and assessment* of auditory dysfunction, the development of *rehabilitation* approaches and techniques, and the *prevention* of hearing loss. We carry out clinical trials, develop technologies, and play an important role in cultivating the next generation of auditory researchers through education and mentoring programs.

Progress to date: Core funding of the Center has been effective in developing one of the country's premier centers for auditory research, and has facilitated the acquisition of investigator-initiated research funds from diverse sources. The NCRAR is a productive VA RR&D Center of Excellence, staffed by VA researchers, carrying out rehabilitation research and development projects of high priority to the hearing health care of veterans.

Title: Viral induced sensorineural hearing loss: a new treatment strategy

Principal Investigator: Steven Hefeneider, PhD

Co-Investigator: Dennis Trune, PhD

Funding Agency: VA RR&D Total Approved Funding: $660,000

Timeframe: 10/01/05 – 09/30/08

Objectives: Sudden sensorineural hearing loss (SSNHL) is characterized by hearing impairment or deafness that develops during a short period of time. The etiology of SSNHL is not well defined and a variety of causes have been hypothesized. Viral infection has been reported as an underlying cause and is supported by serologic and histopathologic studies. The mechanism of viral induced hearing loss is hypothesized to be induction of inner ear inflammation. Inflammatory cytokines produced in response to viral disease may interrupt the hair cell and ion homeostatic pathways in the cochlea, resulting in a decrease in function and eventual death of hair cells. This study seeks to develop an animal model of viral labyrinthitis and determine the impact of immune suppression therapies on the progression and extent of hearing loss.

Research Plan: Recently, a protein from vaccinia virus, termed A52R was reported to inhibit intracellular signaling initiated by PAMP/TLR interaction, resulting in reduced secretion of proinflammatory cytokines produced by immune cells in response to bacterial and viral products. We generated peptide derivatives from the A52R protein and showed that one of these peptides, termed P13, demonstrated significant inhibition of *in vitro* cytokine production in response to bacterial and viral components. Both bacterial and viral products activate the same intracellular pro-inflammatory pathway, via TLRs. The current proposal will examine the effect of peptide P13 therapy on viral induced inner ear inflammation.

Aim 1: Establish in vivo the effectiveness of peptide P13 to inhibit actuation of a viral induced inflammatory response;

Aim 2: Determine the effectiveness of peptide P13 to reduce inner ear inflammation and limit hearing loss in an animal model of viral induced inner ear disease.

Methods: Aim 1will determine whether peptide P13 inhibits pro-inflammatory cytokine secretion from virally stimulated cells in vitro. Established cell lines will be incubated with various concentrations of virus involved in inner ear inflammation and production of pro-inflammatory cytokine secretion quantified by ELISA. Once optimal *in vitro* parameters are established, peptide P13 and a control scrambled peptide will be added simultaneously with the virus and inhibition of pro-inflammatory cytokine secretion determined. Aim 2 will determine whether peptide P13 will limit inflammation and restore hearing thresholds in an animal model of viral induced inner ear disease. Animals will receive bilateral viral injections, one ear with PBS and the opposite ear with various doses of peptide P13. After seven days, hearing levels will again be assessed by ABR, animals will be euthanized and inner ear tissues evaluated histologically for inner ear inflammation.

Findings to date: Peptide P13 has been demonstrated *in vitro* to be a potent inhibitor of viral-induced cytokine release.

Milestone: The VA has asserted ownership and patent rights to an invention disclosed by Dr. Hefeneider as “Identification of a peptide that inhibits toll-like receptor (TLR) signaling: possible application as an anti-inflammatory agent.” Under a Collaborative Technology Administration Agreement between the VA and Oregon Health & Science University, the university has offered to license the technology.

Non-VA Submissions (n = 6; total requested funding = $2,832,380)

Title: A joint DoD-VA Hearing Loss Prevention Program (HLPP)

Principal Investigators: Stephen Fausti, PhD; Marjorie Leek, PhD

Funding Agency: DoD-VA Joint Incentive Funding Health Care Sharing Initiative

Total Requested Funding: $981,798

Timeframe: Two years requested funding (scored, not funded; resubmitting in 2007)

Objectives: The major, long-term goals of this project are to prevent hearing loss in soldiers and veterans, consequently reducing the cost of conditions related to such loss. This program focuses upon education and behavior change as the keys to minimizing further hearing loss. The project seeks to create a multimedia Hearing Loss Prevention Program that can be delivered in a hearing conservation program site or a primary care or other medical setting. For this initial stage of our project, we are targeting soldiers in the hearing conservations programs at Ft. Lewis WA and Ft. Bragg NC, as well as veterans who come to the Portland VAMC for health care. Targeting these individuals extends and supplements existing DoD hearing conservation services, and will reach veterans who may not yet be enrolled in hearing health care services at the VA.

Plan: To address these problems and to reinforce and extend the hearing conservation services offered to active duty soldiers, we propose to create Hearing Conservation Units (HCUs) to be placed, initially, in three locations: one at Ft. Lewis, WA; one at Ft. Bragg, NC; and one at the Portland VAMC. The HCUs will include sound-treated hearing conservation "kiosks" that will be lightweight sound-treated booths in which the hearing health care program can be presented by computer. The HCUs will include computer-presented, interactive modules or programs that provide hands-on education and training about hearing loss and tinnitus, allow self-monitoring of hearing sensitivity through a screening program, provide individualized instruction and evaluation for the use of hearing protective devices (HPDs) and test for proper HPD use by the individual user. A scientifically-accurate simulation of different configurations and severity of hearing loss and tinnitus using realistic soundscapes such as battle sounds or social interactions will provide an entertaining, but sobering, demonstration of the value of preserving hearing. Also included will be a module that provides information concerning audiological services available in the military and VA health care systems, and how those services may be accessed. A discussion of procedures for a seamless transition into the VA system will be presented, including the process of establishing a service connection for auditory disabilities.

Methods: There are three components to the proposal: one is the modification and further development of education and training modules for preventing hearing loss and tinnitus to make them specifically appropriate for these populations; second is the programming and integration of the computer modules and the user interface; and third is the construction of the kiosk-sound booths for the delivery of the program. In theory, each of these components is independent, but in practice, they require one another to deliver the program at the optimum level. At the end of the first six months, the computers will be installed at Madigan/Ft. Lewis, Ft. Bragg, and the Portland VAMC. A half-time audiologist will be hired at each site to monitor use, contact local commanders and other personnel who might be interested in the benefits of the HCUs, develop brochures and fliers to encourage use and announce availability of the systems, and answer questions from HCU users.

Findings to date: The several stages of development for this project are currently underway, including development of training software, and modules for fitting hearing protection and for simulating hearing loss.

Title: Ecological momentary assessment in hearing research

Principal Investigator: James Henry, PhD

Funding Agency: NIH (NIDCD) Total Requested Funding: $100,000

Timeframe: Two years requested funding (pending outcome of scientific peer review)

Objectives: The two most common auditory disorders among aging middle-aged Americans are hearing loss and tinnitus. Approximately 32% of those 55 years of age or older have self-reported hearing loss and about 8% of all adults currently report that they experience a "ringing or buzzing in the ears" daily or "all of the time." Recent data indicate that the prevalence of both hearing loss and tinnitus are increasing in the United States both with and without control for age. However, a much smaller proportion seek treatment for tinnitus or hearing loss. Indeed, only about 25% of those with adult-onset hearing loss currently use hearing aids and some data have shown that only about 37% of adults who say that they have "constant ringing in the ears" have reported this condition to a health care professional. Studies utilizing standard questionnaire methods have shown that those suffering from both hearing loss and tinnitus report that their problems and distress are often episodic, transitory, and situational. Several decades of research in cognitive psychology have shown that there are known and predictable biases in the way people recollect and report health problems and symptoms, particularly that may wax and wane in severity or occur more frequently in specific situations. In an effort to provide a more sensitive measure of the day-to-day real-life experiences associated with health problems, clinical researchers in a variety of fields have turned to a technique known as *ecological momentary assessment* or EMA. It is the objective of the proposed project to conduct pilot studies examining the applications of EMA methods to both hearing loss and tinnitus.

Research Plan: To utilize EMA, a standard Personal Digital Assistant (PDA) is programmed to signal a patient/participant with an audible or vibratory alert at either preset, random, or participant-chosen time points. This alert serves as a prompt to provide a series of assessments using a PDA stylus and touch screen. By asking individuals to provide reports of symptoms, distress and situations close to the time of occurrence, recall and report biases may be substantially reduced and diurnal or other forms of temporal variation in symptoms or distress may be examined. The findings and methods developed in these two studies will guide future clinical research using EMA technologies. Further, as the technologies underlying portable computing devices and hearing assistive devices converge, these pilot studies may serve as the foundation for a future program of research integrating both audiometric and questionnaire-based data streams in real-life day-to-day settings.

Methods: In Study 1, we will examine temporal and situational ratings of hearing difficulty and distress for a 1-week period before and after 24 research participants have received a new and more technologically advanced hearing aid. In Study 2, we will examine situational and temporal variation in ratings of tinnitus severity and distress for a 2-week period in 24 research participants who have previously reported experiencing severe tinnitus. In both studies, data obtained with EMA methods will be compared to standard clinical assessment tools and methods.

Findings to date: The study is pending outcome of scientific peer review.

Title: Hearing Therapies for the Future

Principal Investigator: Gabrielle Saunders, PhD

Co-Principal Investigator: Dawn Konrad Martin, PhD

Funding Agency: NIH (NIDCD) Total Requested Funding: $20,800

Timeline: 09/26/07 – 09/28/07 (scored, pending outcome of funding level determination)

Objective: The National Center for Rehabilitative Auditory Research (NCRAR) will hold its 3rd Biennial International Conference September 26th to 28th, 2007. The primary goal of the conference is to facilitate the rehabilitation of auditory impairment through the translation of basic and applied research findings into audiological clinical practice. The objective of this conference is to expand understanding and facilitate effective treatment of noise induced hearing loss (NIHL).

Education Plan: To accomplish our objective, conference sessions will combine varied formats to stimulate learning, discussion and information dissemination among scientists who are leaders in the field of prevention, treatment, and rehabilitation of NIHL, and audiologists who stand to gain knowledge that is directly applicable to their clinical practice. The rationale for targeting clinicians is that there are many academic conferences in the field of audiological research, but there are few meetings aimed at clinical audiologists at which core clinical issues are traced to their basic and applied research origins.

Methods: The conference is titled "Hearing Therapies for the Future", and will address current understanding of NIHL from cellular, molecular, and clinical perspectives. The conference will include presentations by invited speakers who are leading researchers in the field, round table discussions among scientists, clinicians and hearing impaired lay persons, and a display of posters by clinicians and researchers attending the meeting. In addition, there will be a keynote address by a scientist that has a profound hearing impairment which will provide participants with an assessment of the scope of the problem of NIHL from his unique perspective.

Findings to date: This conference is planned for September 26th – 28th, 2007, and thus there are no findings to report at this time. The meeting will begin with an opening reception and keynote address on the first evening followed by two full days of presentations and an evening poster session. There will be four main conference sessions. At each session, two or three renowned researchers in the field of NIHL will each give 30-45 minute invited presentations. Following the presentations there will be roundtable discussion panels among researchers, experienced clinical audiologists and invited lay persons with hearing impairment. Finally there will be a poster session for posters presented by scholarship winners and by individuals whose submitted posters meet the peer review criteria for acceptance.

The target audience is clinical audiologists, however in past years researchers, medical personnel and students have also attended the NCRAR conferences. Up to eight scholarships will be awarded to practicing clinicians that will cover the cost of conference attendance. The meeting will be publicized via e-mailing lists from national and local organizations and through audiology training programs. Conference proceedings will be published in the scientific peer reviewed journal *Seminars in Hearing*.

Title: Limiting inflammation in bacterial meningitis by targeting host immune pathways

Principal Investigator: Steven Hefeneider, PhD

Co-Investigator: Dennis Trune, PhD

Funding Agency: NIH (NIAID) Total Requested Funding: $275,000

Timeframe: Two years requested funding (scored, not funded; resubmitting in 2007)

Objectives: Bacterial meningitis is an inflammatory disease of the meninges that enclose the brain and spinal cord and is associated with complications including brain damage, hearing loss, learning disabilities, seizures, and motor handicaps. The host inflammatory response to the pathogen, rather than the pathogen itself, is largely responsible for the damage that results from bacterial meningitis. The host inflammatory innate immune response is initiated by activation of intracellular pro-inflammatory signaling pathways. The TLR/IL-1R signaling pathway, which is activated by the interaction of bacterial components with host Toll-like receptors (TLRs) or by the pro-inflammatory cytokine IL-1, results in production of pro-inflammatory cytokines, chemokines, enhanced expression of cell-adhesion molecules, and production of reactive oxygen species and reactive nitrogen intermediates. In bacterial meningitis, these inflammatory mediators cause the breakdown of the blood-brain barrier and formation of brain edema, leading to clinical disease development. Corticosteroids, given before or concomitantly with antibiotics, are the only anti-inflammatory therapy that have shown efficacy in humans. New treatment strategies that selectively target the host inflammatory innate immune response in bacterial meningitis are needed. We have recently identified and characterized a peptide, derived from the A52R vaccinia virus protein, that i) inhibits the in vitro production of pro-inflammatory cytokines and chemokines in response to a variety of TLR ligands, and ii) functions in vivo to significantly reduce bacterial-induced inflammation in a mouse model of middle ear inflammation. We propose in this study to test the feasibility of this peptide as a new treatment to reduce inflammation and limit disease development in bacterial meningitis.

Research Plan: This proposal addresses the hypothesis that use of a novel anti-inflammatory reagent, termed peptide P13, will inhibit production of inflammatory mediators initiated both by bacterial products and pro-inflammatory cytokines, and thereby reduce inflammation and limit disease development in bacterial meningitis. Initial in vitro experiments will establish the effectiveness of peptide P13 to inhibit inflammatory mediators produced by immune cells in response to heat-killed S. pneumoniae or IL-1. Following these studies, the effectiveness of peptide P13 to inhibit inflammation and thereby limit disease development will be examined using a murine in vivo model of S. pneumoniae induced meningitis.

Methods: The proposed studies will employ both in vitro and in vivo assessments of immune function to evaluate the potential therapeutic potential of peptide therapy in meningitis. The in vitro studies will utilize the following established cell lines: *i)* macrophages (RAW264.7), *ii)* endothelial cells (bEND.3), and *iii)* microglial cells (C8-B4), for assessment of inflammatory mediators produced in response to incubation with heat-killed S. pneumoniae. In vivo studies will use BALB/c mice (6-8 weeks of age and weighing 18-22 g) injected with 15 :L of either PBS (negative control) or heat-killed S. pneumoniae (concentration *range* 10^5, 10^7, or 10^9 CFU/ml) into the cisterna magna. The mice will be treated with peptide and then assessed for inflammatory parameters and clinical evaluation of disease development.

Findings to date: Our data to date suggest that middle ear disease and systemic cytokine levels are controlled by the peptide. Therefore, we expect to be able to control brain cytokine levels elevated by the bacteria.

Title: Noninvasive blood glucose monitoring using otoacoustic emissions

Principal Investigator: Eric Wan, PhD

Co-Investigator: Peter Jacobs, MSEE

Funding Agency: NIH (NIDDK) Total Requested Funding: $379,782

Timeframe: Two years requested funding (scored, not funded; resubmitting in 2007)

Objective: The long-term goal of this study is to develop a portable handheld device that patients and clinicians may use to monitor blood glucose noninvasively without the need for painful finger sticks. The objective is to determine the extent to which blood glucose levels in type I diabetic subjects can be measured using masked evoked otoacoustic emissions (OAE). There is evidence that suggests that OAE amplitudes and latencies correlate with glucose. Our hypotheses are that: 1) amplitude and latency measures within an OAE will correlate with blood glucose levels in healthy non-diabetic and in type I diabetic subjects; and 2) there will be a more pronounced correlation when presenting contralateral masking noise while evoking the OAE. To achieve our objective and confirm our hypotheses, we propose the following specific aims: 1) determine whether certain types of audio stimuli and masking conditions evoke OAEs from the cochlea that correlate with blood glucose levels; and 2) develop parametric and non-parametric models that could be used to predict blood glucose levels in a diabetic patient given certain independent variables extracted from the OAE measurement, including amplitude and latency.

Research Plan: A total of 15 healthy, non-diabetic subjects and 30 type I diabetic subjects who take insulin on a daily basis will serve as the subjects in this study. Subjects will be screened to determine which audio stimuli patterns evoke optimal OAE responses to contralateral noise, ipsilateral noise, or both noise types. Test subjects will undergo a glucose tolerance test (GTT) to manipulate their blood glucose levels over a clinically wide range of values. Evoked OAEs will be recorded regularly throughout the GTT. Data analysis will help determine whether a correlation exists between OAE measures and the subjects' blood glucose levels relative to control groups. Mathematical models predicting glucose will be developed and validated using OAE measures.

Methods: All test subjects will be divided into two groups, a Test Group and a Control Group. In the first experiment, healthy subjects will be tested to determine the optimal audio stimulus patterns required to evoke an OAE most significantly affected by noise masking. In the second experiment, healthy subjects will have OAE measurements taken while they undergo a two-hour GTT. During the GTT, the Test Group will ingest a drink containing 75 grams of glucose ½ hour into the study while the Control Group will ingest water. Diabetic subjects will go through the same two experiments described above. The only difference in the protocol is that in experiment 2, diabetic subjects will be required to take a small dose of insulin 1.5 hours into the study to bring their glucose levels back down. Subjects will repeat experiment 2 on consecutive days as we assess short-term drift in the OAE response. Subjects will also be tested approximately 1 month after the initial experiment is run to determine long-term drift in the OAE responses.

Findings to date: Preliminary experiment were done on one healthy non-diabetic subject. OAEs were measured during a GTT under contralateral noise masking, forward masking, and no masking conditions. OAEs evoked during contralateral and forward noise masking conditions correlated with glucose in a multivariable linear regression between glucose levels and OAE amplitudes / latencies (R-Squared = 0.76). A less significant correlation was observed when OAEs were evoked without contralateral masking. The preliminary findings support our hypothesis and provide justification for further research.

Title: Using chronic pain models to develop tinnitus evaluation and treatment methods

Principal Investigator: James Henry, PhD

Co-Principal Investigator: Robert Folmer, PhD

Funding Agency: NIH (NIDCD) Total Requested Funding: $1,075,000

Timeframe: Five years requested funding (under review)

Objectives: Many similarities exist between chronic tinnitus and chronic pain. For example, the severity of both symptoms is positively correlated with anxiety, depression, insomnia, and catastrophic thinking. These similarities prompted several experts to recommend that pain evaluation and management strategies be applied to tinnitus patients. However, these suggestions have not been implemented or studied systematically. The long-range goal associated with this research program is to improve tinnitus evaluation and treatment methods by applying principles of effective pain management to tinnitus patients. The objective of this proposed research is to determine the relationships among tinnitus severity, catastrophic thinking, and physiological levels of cortisol and pro-inflammatory cytokines.

Research Plan: The proposed study is designed as a prospective non-randomized observational study. The study will determine the level of static correlation between catastrophic thinking (as measured by the tinnitus-modified Catastrophizing Thinking Scale—CTS) and tinnitus severity (as measured by the Tinnitus Handicap Inventory—THI) versus saliva and blood physiological markers, and to determine the level of dynamic correlation in the change in these measurements following an intervention. Intervention will involve eight group sessions of cognitive-behavioral therapy that is specially designed to reduce catastrophic thinking. The treatment will be used as a means of reducing catastrophic thinking and perceived tinnitus handicap. A collaborative, multi-disciplinary research team has been assembled that combines the diverse range of psychosocial, statistical, and clinical expertise needed to achieve definitive outcomes. Participating organizations include the Tinnitus Clinic at Oregon Health & Science University (OHSU), the OHSU Clinical and Translational Research Center, the OHSU Comprehensive Pain Center, Portland VA National Center for Rehabilitative Auditory Research, and the Cousins Center for Psychoneuroimmunology at the University of California, Los Angeles.

Methods: Screening will be conducted to identify 180 subjects who experience tinnitus across a wide range of severity levels. Each subject will receive an otolaryngological evaluation to identify any medical conditions that require treatment or would exclude individuals from participating in the study. Subjects will also receive an audiological exam. They will then complete the CTS and THI questionnaires and various psychosocial rating scales. In addition, saliva and blood samples of cortisol, and IL-1β, IL-1ra, IL-6, and TNF-α components of inflammatory cytokines will be collected and processed. This testing will be repeated following administration of the CBT intervention. The CBT will involve eight weekly sessions in cohorts of 8-10 subjects.

Findings to date: The study is pending outcome of scientific peer review.

Non-VA Approvals (n = 6; total funding received = $2,658,043)

Title: Auditory modeling of suprathreshold distortion in persons with impaired hearing

Principal Investigators: Brian Walden, PhD; Marjorie Leek, PhD; Kenneth Grant, PhD; W. Van Summers, PhD (multi-site between Walter Reed Army Medical Center and the NCRAR)

Funding Agency: The Oticon Foundation Total Approved Funding: $1,812,768

Timeframe: 02/01/06 – 01/31/09

Objectives: Current hearing aids generally do an excellent job of compensating for the loss of sensitivity resulting from hearing impairment, but they are quite limited in their ability to address suprathreshold forms of distortion. Greater use of amplification by persons with impaired hearing may depend upon the development of signal processing algorithms that restore more normal suprathreshold auditory function. The research proposed in this application is intended as a precursor to the development of effective "reverse engineering" approaches to restoring more normal suprathreshold auditory function in persons with impaired hearing; that is, signal processing strategies that alter incoming auditory signals in such a way that, after processing by the impaired auditory system, more normal neural input to the brain is achieved.

Research Plan: Although conceptually familiar to hearing aid software engineers, preprocessing of the incoming auditory input to compensate for distortions imposed by the impaired auditory system has not been practical because of an inability to describe patient-specific distortions in a way that is amenable to familiar signal-processing approaches. This research seeks to take advantage of recent computer-based auditory processing models that provide visual and mathematical representations of auditory input at various stages of neural processing. Several measurements of auditory function will be taken on a small set of subjects in order to completely characterize their individual auditory systems. These will include measures of threshold, auditory frequency and temporal resolution, modulation perception, and auditory-visual integration ability. These measures will be used to parameterize auditory models in order to predict speech perception in noise and reverberation by the individual listeners. The adequacy of these representations will be evaluated by determining if they are sufficient to predict certain behavioral measures of auditory and auditory-visual speech recognition in these patients.

Methods: Psychoacoustic (behavioral) tests will be carried out by listeners with various types and configurations of hearing loss. In all experiments, listeners will be asked to listen over earphones to specially constructed sounds and indicate their ability to detect, discriminate, or identify them by touching designated areas on a touch-screen monitor or by pushing buttons on a response box. The sounds to be tested will vary depending on the exact experimental question that is being asked. As information becomes available about individual subjects, auditory models will be modified to attempt to predict the performance of that subject on evaluation studies of speech perception under noise and reverberation. The available computer models typically emphasize processing at different levels of the auditory ear-brain system, and the combination of the most successful of these models will lead to predictions of speech recognition performance for a given hearing impaired subject, that will be compared to actual measured performance.

Findings to date: In the first study of the grant, notched-noise masking psychoacoustic measures have supported the estimation of auditory filter shapes and bandwidths for five subjects at the Portland site and four subjects at Walter Reed Army Medical Center. In normal-hearing people, filter bandwidths broaden with increasing probe level, but hearing-impaired subjects' bandwidths do not, because the auditory filters are already broad due to the impairment. Testing of additional subjects and stimulus conditions is currently underway.

Title: Identification of ambiguous vowel stimuli in noise by hearing-impaired listeners

Principle Investigator: Michelle Molis, PhD

Funding Agency: OSHU Medical Research Foundation Total Approved Funding: $15,000

Timeframe: 12/01/06-11/30/07

Objectives: Hearing impairment frequently results in reduced frequency selectivity in the auditory periphery. Additionally, there is a loss of perceptual sensitivity which requires that inputs be presented at increased levels to ensure audibility—a step that may further decrease frequency selectivity. The result is a smoothed internal representation lacking unambiguous spectral prominences corresponding to formant frequencies. The introduction of a competing background noise further exacerbates this situation. Since, optimal vowel exemplars are rarely produced by speakers in real world situations; there is extensive overlap between category tokens. This stimulus ambiguity makes understanding speech in everyday listening situations an even greater challenge for individuals with hearing loss. An evaluation of vowel identification with ambiguous stimuli in the presence of competing noise will provide a more realistic evaluation of listeners' capabilities than is commonly provided in a laboratory setting. This study will compare patterns of vowel identification in noise between and among hearing-impaired and normal hearing listeners.

Research Plan: Two groups of listeners will participate in this investigation: a normal hearing group and a hearing-impaired group. The identification patterns for three different subsets of synthesized vowel stimuli will be collected.

Methods: Vowel stimuli will be drawn from semi-regularly sampled stimulus spaces varying either in first and second formant frequencies or second and third formant frequencies. These vowel sounds will be presented to subjects over earphones along with speech-shaped background noise at several signal-to-noise ratios. On each trial, listeners will be asked to assign stimuli to one of three vowel categories by pressing buttons on a labeled response panel. This task will produce response frequency profiles for each of the possible response categories.

Findings to date: It is expected that the responses of the hearing-impaired listeners will be more variable than the responses of the normal hearing listeners at all signal-to-noise ratios. Furthermore, it is expected that this variability will be even greater for the stimuli that vary in second and third formant frequencies. Response patterns will likely relate to degree of hearing loss and impairment of peripheral frequency selectivity.

Title: Otitis media impact on the inner ear

Principal Investigator: Dennis Trune, PhD

Funding Agency: NIH (NIDCD) Total Approved Funding: $275,000

Timeframe: 07/01/06 – 06/30/08

Objectives: The goal of this research is to identify how inflammatory processes in the middle ear cause cochlear dysfunction. The PI, in collaboration with colleagues, has recently developed an acute otitis media mouse model, as well as described chronic otitis media in the C3H/HeJ mouse that has a defect in its toll like receptor 4 (TLR4). Furthermore, these collaborations have led to the development of new methods to characterize both middle ear and inner ear cytokine expression, NF-kB-mediated inflammatory processes, nitric oxide-mediated cochlear damage, and quantitative immune cell pathology. The proposed studies will capitalize on both these acute and chronic middle ear disease mouse models to establish the correlative middle ear and inner ear immune mediated processes. This will describe for the first time the molecular immune mechanisms by which otitis media can directly cause inner ear pathology. Therefore, this research has the potential to significantly advance our understanding of inner ear inflammatory processes elicited by both acute and chronic otitis media and lay the groundwork for development of new procedures for the detection and therapy of such hearing loss.

Research Plan: The specific aims of this proposal are:

Aim 1: To characterize the inner ear inflammatory processes in acute otitis media. This will clarify immune-mediated processes in the cochlea elicited by short-term middle ear infections.

Aim 2: To characterize the inner ear inflammatory processes in chronic otitis media. This will clarify inner ear immune-mediated processes that can result from chronic middle ear infections.

Methods: The proposed studies will utilize BALB/c mice inoculated in the middle ear with heat-killed *Haemophilous influenza* or *Streptococcus pneumoniae* (acute otitis media) and C3H/HeJ mice defective for TLR4 (chronic otitis media) to characterize inner ear pathology, physiology, cytokine gene expression, cytokine levels, NF-kB activated inflammatory processes, and reactive oxygen species. Inner ear pathology will be measured with auditory brainstem response audiometry, the endocochlear potential, light and electron microscopy, and immunohistochemistry of inflammatory mediators. Cochlear immune-mediated processes will be assessed by measurement of inflammatory cytokines, cytokine gene expression, and ELISA of transcription factors, vascular related factors, and reactive oxygen species.

Findings to date: The inner ear tissues will express cytokine RNA in response to both acute and chronic otitis media. PCR shows this expression is quantifiable and increased after inflammatory mediators from the middle ear impact such expression in the inner ear.

Title: Pre-doctoral summer training program in auditory research

Principal Investigator: Marjorie Leek, PhD

Funding Agency: NIH (NIDCD) Total Approved Funding: $124,025

Timeframe: 05/01/07 – 04/30/12

Objectives: This proposal is an initiative of the National Center for Rehabilitative Auditory Research (NCRAR) to provide a stimulating and productive summer research experience for four predoctoral graduate students enrolled in AuD programs. NCRAR investigators work toward the common goal of decreasing hearing disability through multidisciplinary research programs addressing diagnosis and assessment, rehabilitation and prevention in areas of audiology, psychology, neuroscience, neurology, otolaryngology and engineering. The breadth of experimental approaches, coupled with the common focus on clinically-relevant significant problems of hearing-impaired patients provides us an opportunity to offer research training that may be unique within the nation's universities and research organizations.

Education Plan: This summer training program will provide a mechanism for a short term immersion of promising AuD graduate students into ongoing clinical research. Predoctoral trainees will be recruited nationally from all accredited AuD programs. The research activities available to the summer trainees will be varied and stimulating. Students will be assigned one or two faculty mentors, selected according to the student's interests and the mentors' availability.

Methods: The students will work within the context of the research area of the primary mentor(s), with varying degrees of independence. Ideally, the trainees who participate in this program will be able to manage a small research study of their own. Across-laboratory interactions will be encouraged. There will be weekly seminars provided by the faculty, which will include discussions and instruction in research ethics, and the process of carrying out a research project from design to publication. Some of the weekly seminars will include presentations by scientists from other institutions in the Portland area, discussing their work and its relevance to clinical audiology. Trainees will be expected to end their training program by developing an oral presentation describing their research during the summer.

Findings to date: The NCRAR has received word that this training grant will be funded by NIH, starting summer 2007. Realistic expectations are that only a fraction of the students will be attracted to a change in direction into a research career, but some will, and the others will emerge from the summer with a clear appreciation for the process of research and will recognize the importance of research to the foundations of their clinical training and the continued growth of audiology as a profession. It is anticipated that an additional benefit of this program will be the opportunity for students from different universities to learn from each other and start to form nationwide collegial relationships that will last throughout their careers.

Title: The ability to make multiple auditory judgments about non-speech stimuli

Principal Investigator: Frederick Gallun, PhD

Funding Agency: NIH (NIDCD) Total Approved Funding: $242,250

Timeframe: 02/01/07 – 01/31/10

Objectives: Listeners in constantly changing noisy environments often experience more difficulties than when the same noise level is present but the environment is not changing so rapidly. This is a particular problem for those with even mild hearing loss (McCoy et al., 2005). Improving understanding of the processes by which a rapidly changing auditory environment is analyzed by listeners with impaired hearing will lead to improved creation of appropriate therapies and devices to reduce the difficulties such listeners experience.

Research Plan: 40 listeners, equally divided among normally-hearing and hearing-impaired and younger and older listeners will make judgments about brief (50 ms) changes in the amplitude (increase vs. decrease), frequency (higher vs. lower) and/or perceived location (left vs. right) of easily distinguished narrowband noise bursts

Methods: Noise bursts will be centered on three frequencies: 758 Hz, 2013 Hz and 5085 Hz). The lowest frequency will be presented to both ears, the middle monaurally to the left ear and the highest monaurally to the right ear. Judgments will be made sequentially or simultaneously as well as within or across frequency regions. In the first set of experiments, pre-stimulus or post-stimulus cues will alert the listeners to the frequency band to judge but each feature will be associated with a single frequency band. A pre-stimulus cue allows selective attention to a single frequency band (and feature) while a post-stimulus cue requires divided attention across all three bands. Location judgments will be associated only with the lowest band. A second experimental manipulation will involve changes in amplitude, frequency or location in the lowest frequency band. In this case, the cue indicates the judgment to be made rather than the frequency band. Pre- and post-stimulus cues will again be investigated. It is hypothesized that primary limitations in making multiple judgments involve: 1) short-term memory processes; and 2) sharing resources within and between auditory processing mechanisms. The influence of aging is expected to be profound and an equally substantial effect of hearing loss is anticipated based on studies such as that of McCoy et al. (2005).

Findings to date: The study has recently been funded and the start date has been delayed in order to allow transfer of the PI to the NCRAR; therefore there are no findings to report at this time.

Title: Temporal resolution of cochlear and auditory nerve responses in older adults

Principal Investigator: Dawn Konrad-Martin, PhD

Funding Agency: NIH (NIDCD) Total Approved Funding: $189,000

Timeframe: 04/01/06 – 03/31/09

Objectives: Older adults have greater difficulty understanding speech compared with younger adults, even when hearing sensitivity is similar between the two groups, possibly due to impaired perception of time-varying speech cues. The decline in temporal resolution that accompanies aging is due to an unknown mixture of peripheral (cochlear and auditory nerve), central auditory, and cognitive processing deficits. Objectives of this work are to determine: (1) whether auditory nerve synchrony is reduced and recovery from prior stimulation is prolonged in older ears; (2) the extent that age-related changes in cochlear function can account for changes in the amplitude and timing of auditory nerve responses, and; (3) whether age-related changes in cochlear mechanical and auditory nerve responses alter the perception of temporal speech cues by older listeners.

Research Plan: Groups of older and young adults with normal or impaired hearing will serve as subjects. Neural responsiveness is explored in each of the 4 groups by comparing unmasked to forward-masked compound action potentials (CAP). Measures of temporal resolution based upon CAP data are obtained using a forward-masking paradigm. The contribution of the cochlear-driven otoacoustic emission (OAE) measurements is compared to the neural-driven CAP to determine if changes in cochlear mechanics influence changes in neural responsiveness. Finally, results of speech recognition tests for stimuli that vary in their voice onset time are compared to cochlear and neural responses in order to make inferences about the relationship between speech recognition performance and peripheral auditory system function. Results will determine the extent to which poor temporal resolution and specific physiological changes within the auditory periphery account for age-related deficits in the processing of temporal aspects of speech.

Methods: Four groups totaling 120 subjects will participate in this study (2 groups of 40 elderly individuals and 2 groups of 40 young subjects). Elderly subjects are $\geq$ 63 years with normal hearing or cochlear hearing loss (high frequency pure-tone-average [HFPTA] = 30-50 dB HL). Young subjects are 18 to 35 years old with normal hearing or with noise-induced hearing loss (HFPTA = 30-50 dB HL). Procedures include pure-tone audiometric assessment of conventional and ultra-high frequencies, physiological assessment (tympanometry, measures of temporal resolution based upon auditory nerve compound action potentials (CAPs) obtained using a forward-masking paradigm, estimates of cochlear mechanical compression and travel time from OAEs; and (3) determine the extent to which performance on a temporal speech task depends upon cochlear mechanical and auditory nerve responses in the auditory systems of the elderly.

Findings to date: Pilot data have been analyzed data to determine durations and frequencies needed to produce OAEs from brief stimuli that have amplitudes similar to that obtained using a continuous tone. We have completed the custom OAE software, generated OAE stimuli, refined the OAE protocol and implemented an energy-based method for estimating levels of stimuli reaching the eardrum. We have customized the off-the-shelf CAP software. The CAP protocol is being refined based on incoming data. Programming for psychoacoustic and speech perception measurements is underway. We have enrolled 13 subjects to date.

Ongoing non-VA (n = 5; total funding received = $4,698,316)

Title: Core center

Principal Investigator: Peter Gillespie, PhD

Co-Investigator: Dennis Trune, PhD

Funding Agency: NIH (NIDCD) Total Approved Funding: $2,062,861

Timeframe: 04/01/03 – 03/31/08

Objectives: The major goals of this project are to centralize expertise on bioengineering, imaging, and mouse genetics in order to enhance presently funded research projects and stimulate collaborations between participating investigators.

Research Plan: The objectives are to be achieved through three Core research facilities:

1. Bioengineering will provide computer hardware and software support for measurement of hearing;
2. Imaging will centralize existing OHRC confocal and electron-microscopic imaging;
3. Mouse Genetics will provide mouse husbandry and genotyping for transgenic and gene-targeting constructs.

Methods: The methods for subproject "Imaging" Core (D. Trune, PI) are to provide microscopy and histology services for grant participants.

Findings to date: Thus far, the Imaging Core has trained or assisted research investigators or technical staff of approximately 20 laboratories. Considerable assistance has been provided for laser confocal microscopy, as well as preparation of cryostat sectioning of the ear for immunocytochemistry. New mouse models have been established for ion homeostasis disorders of the ear and these will be characterized in the coming months.

Title: Development and evaluation of an outcome measure for tinnitus

Principal Investigator: Mary Meikle, PhD

Co-Principal Investigator: James Henry, PhD

Funding Agency: Tinnitus Research Consortium Total Approved Funding: $291,435

Timeframe: 07/01/04 – 06/30/07

Objectives: A new outcomes instrument for measurement of the severity and negative impact of tinnitus will be developed in a multi-site study conducted by the Oregon Health & Science University in conjunction with three other clinical sites located in Ohio, Florida and Oregon, respectively.

Research Plan: An Outcomes Working Group (consisting of the eight co-investigators, assisted by outcomes consultants with psychometric and biostatistical expertise and an Advisory Panel of tinnitus experts) will be set up to develop the self-report questionnaire. It will be designed for use in (1) assessing the severity and negative impact of tinnitus in affected individuals, and (2) use in evaluating treatment-related changes in tinnitus. Responses from 1200-1500 tinnitus patients (with tinnitus ranging in severity from mild to severe) will be studied at the various sites over the 3-year period.

Methods: Using a systematic development protocol, a prototype questionnaire was developed during the first 6 months of Year 1. The prototype questionnaire is being administered to all subjects at intake and to those requesting treatment (approximately half of the group) at 3, 6, and 9 months following the initiation of their treatment. The resulting data will be entered into a database for statistical evaluation. A variety of statistical techniques, including correlational and other factor-analytic techniques will be used to evaluate psychometric characteristics of the instrument (validity, reliability) and its responsiveness to change will be evaluated using a hierarchical linear model to test whether treated subjects show significant tinnitus improvement compared to wait-listed controls. Based on preliminary findings with the first prototype, in Years 2-3 a second prototype questionnaire will be developed and evaluated at the various sites, using similar statistical procedures. It is anticipated that the final product, the "Tinnitus Functional Index" or TFI, will exhibit desirable psychometric characteristics that are well-adapted to its various intended uses.

Findings to date: Testing and evaluation of the Phase I prototype was completed in 2006, and Prototype 2 was developed based on those results. Prototype 1 was found to function very well as both a measure of individual differences in regard to tinnitus severity and negative impact, and as a measure of treatment-related changes in tinnitus. Prototype 2 is now undergoing testing and evaluation in a new group of subjects, with final results and conclusions expected early in 2008.

Title: Hearing loss and the perception of complex sounds

Principal Investigator: Marjorie Leek, PhD

Funded Agency: NIH (NIDCD) Total Approved Funding: $938,780

Timeframe: 09/01/03 – 08/31/08

Objectives: Auditory speech recognition by individuals with hearing loss requires recovery of the intended message from a distorted internal representation of the input stimulus. This research is focused on the preservation of temporal precision in auditory processing by hearing-impaired listeners, and how these measures relate to pitch perception. The preservation of precise temporal firing patterns in the auditory nervous system is necessary for the clear perception of pitch that supports recognition of speech sounds as well as for the ability of normal-hearing people to extract the speech signal from a noisy background. An understanding of the interaction of factors such as impaired spectral and temporal processing with the acoustics of speech and music is critical to the potential ability to tailor programmable hearing aids to individual patients' hearing losses.

Research Plan: Each experiment in this grant involves prospective data collection from two groups of up to six subjects. The experimental group will be people with sensorineural hearing loss and a control group will consist of subjects with normal hearing. The listeners will be asked to discriminate among sounds that vary along acoustic dimensions known to be important to auditory processing of speech and other sounds: the frequency spectrum, the temporal waveform envelope, and the temporal fine structure in the waveform. Experiments are also proposed that will estimate the amount of temporal "jitter" imposed by a damaged auditory system in the preservation of accurate neural temporal information across different frequency ranges.

Methods: Listeners will be asked to listen over earphones to specially constructed sounds and indicate their ability to discriminate them by touching designated areas on a touch-screen monitor or by pushing buttons on a response box. The sounds to be tested will vary depending on the exact experimental question that is being asked. For each set of sounds, a mean discrimination threshold and variability will be determined. In a second type of task, listeners will be asked to match the pitches of two types of complex sounds. For this task, the listener will hear two sounds alternating, and will be able to control the pitch of one of them until he/she estimates that they match. The frequency relationships of the matched sounds will be compared to findings in normal-hearing listeners, and the variability of the matches will indicate the stability and strength of the perceived pitch.

Findings to date: Recent studies on this grant have assessed the abilities of hearing-impaired listeners to perceive differences in upsweeping and downsweeping frequency glides, such as found speech sounds, and the ability of hearing impaired subjects to hear differences in the temporal waveforms of complex sounds like speech. Upward gliding frequency sweeps are more difficult to distinguish than downward gliding sweeps for hearing-impaired subjects, possibly explaining some of their difficulties understanding certain speech sounds. We also determined that hearing-impaired listeners were restricted in their ability to discriminate temporal waveforms with short durations. This means that some of the fine structure in speech waveforms may be indiscriminable to these people, which likely interferes with the ability to clearly understand speech.

Title: Research training in Otolaryngology/Head & Neck Surgery

Principal Investigator: Mark Richardson, MD

Co-Investigator: Dennis Trune, PhD

Funding Agency: NIH (NIDCD) Total Approved Funding: $580,240

Timeframe: 07/01/03 – 06/30/08

Objectives: Our research training program has five components:

1. Otolaryngology resident training;
2. Pre-doctoral training for medical students;
3. Pre-doctoral training for basic science PhDs;
4. Post-doctoral training for basic science PhDs;
5. Coordinated interaction between recipients of the training grant and the clinical and research divisions of the department.

Research Plan: The specific aim of this grant is to train senior level otolaryngology residents in research at OHSU. Furthermore, their training is juxtaposed with that of pre- and postdoctoral students for cross fertilization of ideas, techniques, experimental design and interdisciplinary problem solving. This will facilitate the entry of otolaryngology physicians and other young investigators into academic practice or research careers and increase the likelihood of successful extramural funding for their research activities. The time period is a two-year research training program between the fourth and fifth years of OTO/HNS residency. This will allow resident physicians to formulate appropriate research questions and develop longer-term interests. This shorter term between research and academic appointments will enhance resident competitiveness for professional positions. Additionally, the rapidly changing landscape of medicine may mean that a promising area of research may be less relevant in a span of 3-4 years. New developments in the field may also permit pursuit of questions not conceived early in residency training.

Methods: This training grant trains senior level otolaryngology residents in research methodology, critical thinking and science over a two-year period. This time also is used to develop projects that can be submitted as K08 awards or for other extramural funding. Juxtaposing their training with other young investigators embarking on research careers stimulates questions related to clinical problems. Oversight by experienced mentors, successful in grant funding, improves the likelihood of eventual extramural support. Of critical importance is the mix of trainees present in the labs, thus the requested support for residents, PhD post-docs and pre-docs and medical students. The interaction of clinical scientists with basic investigators shapes the development of critical research questions and influences the future directions taken by pre- and post-doctoral candidates. The exposure and training of clinicians in the rigorous processes of an active research lab brings clarity and definition to their research questions, ultimately critical for their success.

Findings to date: Five otolaryngology residents have been selected for the program of two years of research. To select these candidates, ten applicants each year are interviewed. Approximately ten medical students have been funded for summer research projects. Also, each year a new postdoctoral fellow and a pre-doctoral student have been funded for salary. The selection committee, made up of members of the training grant, makes the decision of who gets funding for a year.

Title: Steroid responsive mechanisms in the ear

Principal Investigator: Dennis Trune, PhD

Co-Investigator: Steven Hefeneider, PhD

Funding Agency: NIH (NIDCD) Total Approved Funding: $825,000

Timeframe: 09/01/05 – 08/31/08

Objectives: Although glucocorticoids, such as prednisone, have been employed for decades for control of hearing loss, little is known of the cellular mechanisms of the ear that are under their control. A better understanding of these steroid responsive mechanisms is critical for our design of appropriate therapy. Therefore, the long term goal of this research is to characterize the steroid driven cellular mechanisms of the ear. Preliminary studies have shown hearing loss in the MRL/MpJ-Faslpr autoimmune mouse responds to treatment with both the glucocorticoid prednisolone and the mineralocorticoid aldosterone. It is hypothesized that two steroid-responsive mechanisms exist in the ear: a *direct* sodium and potassium transport (homeostatic) gene expression mediated by the mineralocorticoid receptor, and an *indirect* inflammatory gene suppression mechanism mediated by the glucocorticoid receptor.

Research Plan: The planned studies will characterize these steroid-driven cellular and molecular processes with steroid treatments that will functionally isolate the receptors and measure changes in the cochlear homeostatic and inflammatory gene expression they control. The *specific aims* to investigate these steroid mechanisms of the ear are:

Aim 1: Determine the dose-dependent control of inner ear ion homeostatic and inflammatory gene expression by the mineralocorticoid aldosterone and the glucocorticoid prednisolone;

Aim 2: Determine the most effective control of both inner ear ion homeostatic and inflammatory gene expression processes by combination doses of the two steroids;

Aim 3: Determine which cochlear cellular and molecular functions are mediated by each steroid receptor;

Aim 4: Determine if effective inner ear homeostatic and anti-inflammatory gene expression can be induced by middle ear steroid delivery.

Methods: In all studies, assessment will be made of steroid effects on inner ear structure (light and electron microscopy), function (ABR, EP), cochlear specific antibodies (ELISA), and cochlear gene products (ELISA, cytokine RNA expression, and quantitative RT-PCR). The results from these studies will provide significant new findings regarding the cellular and molecular mechanisms of the ear that are under the control of steroids. This study also will lay important groundwork for the development of alternative steroid therapies that may be more effective than those currently employed for clinical hearing loss.

Findings to date: Treatment of mice with the commercially available mineralocorticoid fludrocortisone was as effective as the natural mineralocorticoid aldosterone in preventing hearing loss. Studies also indicate that the glucocorticoids given for inner ear disease may bind to the mineralocorticoid receptor to improve cochlear ion homeostasis and hearing. Also, the intratympanic delivery of steroids for hearing loss will get steroids into the inner ear quickly, but levels decline by 24 hours. ELISA experiments show that levels of cytokines and inflammatory markers are suppressed by steroid treatments. Blocking the glucocorticoid receptor with RU-486 does not prevent the glucocorticoids from preserving hearing, suggesting the mineralocorticoid receptor is a major player in steroid-responsive hearing loss.

IV. CAPACITY BUILDING

The NCRAR's newly constructed 21,000 square foot Center of Excellence facility is serving as a unique capacity building advantage for attracting junior-, mid-, and senior-level investigators and research career development candidates with new perspectives and stimulating ideas to generate hypothesis-driven rehabilitation research. The NCRAR facility is generously furnished with 9 dedicated auditory research sound attenuation rooms as well as an anechoic chamber and the latest clinical and research instrumentation as shared, core resources. The facility provides optimally functional space, and the center's diverse, yet complimentary, multidisciplinary team creates a unique mentoring and training advantage that is difficult, if not impossible, to accomplish otherwise. During 2006, the NCRAR was privileged to mentor and train the following individuals:

Associate Investigator Awardees

- Frederick Gallun, PhD (M. Leek, Mentor).
- Michelle Molis, PhD (M. Leek, Mentor).

Rehabilitation Research Disability Supplement Awardee

- Mitchel Turbin, PhD (S. Fausti; G. Saunders; J. Henry; K. James, Mentors).

Research Career Development Awardees

- Dawn Konrad-Martin, PhD (S. Fausti, Mentor).
- M. Samantha Lewis, PhD (G. Saunders, Mentor).

Advanced Research Career Development Awardee

- Dawn Konrad-Martin, PhD (M. Leek; S. Fausti, Mentors).

Research Career Scientist Awardee

- James Henry, PhD (S. Fausti, M. Leek, Mentors).

Senior Research Career Scientist Awardee

- Marjorie Leek, PhD.

Visiting Scientist

- Cynthia Fowler, PhD (from University of Wisconsin – Madison).

Otolaryngology Residents

- Bobby Ghaheri, MD, Otolaryngology Resident (D. Trune, Mentor).

Post-doctoral Research Associates

- Kimberly Block, AuD, Research Associate (M. Leek, Mentor).
- Tara Zaugg, AuD, Research Associate (J. Henry, Mentor).

Pre-doctoral Students

- Amanda Lauer, MA, PhD Candidate, University of Maryland, College Park, MD (M. Leek, Mentor).
- Peter Jacobs, MSEE, PhD Candidate, Oregon Graduate Institute, School of Science & Engineering, Oregon Health & Science University, Portland, OR (S. Fausti; E. Wan; D. Erdogmus, Mentors).

Master's Graduate Students

- Kimberly Owens, BS, MPH Candidate, Portland State University, Portland, OR (J. Henry; C. Kaelin, Mentors).
- Kelly Reavis, MS, MPH Candidate, Oregon Health & Science University, Portland, OR (D. Konrad-Martin, Mentor).

Undergraduate Research Students

- Joseph Baird, Electrical & Computer Engineering Student Intern (P. Jacobs, Mentor).
- Brianna Hoffman, Supervised Research Project (D. Trune; S. Hefeneider, Mentors).
- Jordan Tabayoyon, Pre-medical School Student Intern (D. Konrad-Martin, Mentor).

Student Temporary Employee Program Students

- Katie Kalk, Research Student Intern (D. Konrad-Martin, Mentor).
- Mark Lisowski, Research Student Intern (M. Samantha Lewis, Mentor).
- Andrew McGuiness, Research Student Intern (M. Samantha Lewis, Mentor).

NCRAR Staff

Administrative Division

- Bonnie Becker, *Administrative Special Assistant*, 100% Salaried VA.
- Dennis Bourdette, MD, *Associate Director*, 63% Salaried VA.
- Marcia Collins, *Program Support Assistant*, 100% Salaried VA.
- Stephen Fausti, PhD, *Director*, 100% Salaried VA.
- Patrick Helt, MA, *Administrative Officer*, 100% Salaried VA.
- Patricia Saub, *Budget Analyst*, 100% Salaried VA.
- Dennis Smith, MD, *Administrative Advisor*, 0% Salaried VA (independent contractor).

Research Division

- Donald Austin, MD, MPH, *Investigator*, 0% Salaried VA (IPA with academic affiliate).
- Anna Forsline, MA, *Research Audiologist*, 100% Salaried VA.
- Izumi Furukawa, MA, *Research Audiologist*, *100% Salaried PVARF.
- Frederick Gallun, PhD, *Associate Investigator*, 100% Salaried VA.
- Jane Gordon, MS, *Research Audiologist*, 100% Salaried VA.
- Susan Griest, MPH, *Data Specialist*, 0% Salaried VA (IPA with academic affiliate).
- Steven Hefeneider, PhD, *Investigator*, 100% Salaried VA.
- Wendy Helt, MA, *Research Audiologist & Grant Administrator*, 100% Salaried VA.
- James Henry, PhD, *Investigator*, 100% Salaried VA.
- Alisha Holloway, BS, *Research Coordinator*, 100% Salaried VA.
- Michele Hutter, MS, *Research Audiologist*, 100% Salaried VA.
- Christine Kaelin, MBA, *Research Coordinator*, 100% Salaried VA.
- Debra Kelly, RN, *Research Nurse & Research Coordinator*, 100% Salaried VA.
- Dawn Konrad-Martin, PhD, *Investigator*, 100% Salaried VA.

- Marjorie Leek, PhD, *Investigator*, 100% Salaried VA.
- Harry Levitt, PhD, *Investigator*, 0% Salaried VA (independent contractor).
- M. Samantha Lewis, PhD, *Investigator*, 100% Salaried VA.
- David Lilly, PhD, *Investigator*, 70% Salaried VA.
- Daniel McDermott, MA, *Research Audiologist*, 100% Salaried VA.
- Curtin Mitchell, PhD, *Investigator*, 100% Salaried VA.
- Michelle Molis, PhD, *Associate Investigator*, 100% Salaried VA.
- Linda Munoz, MBA, *Research Assistant*, 100% Salaried VA.
- Aynun Naher, *Research Assistant*, 0% Salaried VA (volunteer).
- Kimberly Owens, BS, MPH Candidate, *Research Assistant*, 100% Salaried VA.
- Kelly Reavis, MS, MPH Candidate, *Research Audiologist*, 100% Salaried VA.
- Gabrielle Saunders, PhD, *Investigator*, 100% Salaried VA.
- ShienPei Silverman, MA, *Research Assistant*, 0% Salaried VA (NIH-funded).
- Daniel Storzbach, PhD, *Investigator*, 100% Salaried VA.
- Dennis Trune, PhD, *Investigator*, 0% Salaried VA (IPA with academic affiliate).
- Mitchel Turbin, PhD, *Investigator*, 100% Salaried VA.
- Nancy Vaughan, PhD, *Investigator*, 100% Salaried VA.
- Debbie Wilmington, PhD, *Investigator*, 100% Salaried VA.
- Tara Zaugg, MA, AuD, *Research Audiologist*, 100% Salaried VA.

Technology Design, Development and Support Division

- Joseph Baird, Undergraduate Student, *Electrical Engineering*, 100% Salaried VA.
- Craig Dennis, *Computer & Network Support Technician*, 100% Salaried VA.
- Roger Ellingson, MSCSE, *Hardware/Software Engineer*, *100% Salaried PVARF.
- Joseph Istvan, PhD, *Biostatistician*, 0% Salaried VA (Contract).
- Peter Jacobs, MSEE, PhD Candidate, *Biomedical Engineer*, 63% Salaried VA.
- Kenneth James, PhD, *Biostatistician*, 0% Salaried VA (IPA with academic affiliate).
- David Phillips, PhD, *Biostatistician*, 100% Salaried VA.
- Carol Wolff, MSCE, *Physical Science Technician*, 100% Salaried VA.

Education and Information Dissemination Division

- Carolyn Landsverk, MS, *Education & Public Relations Coordinator*, 100% Salaried VA.

  * (Retained via the Portland VA Research Foundation due to lack of competitive VA employment opportunities)

NCRAR National Advisory Board

- Walter J. McDonald, MD, FACP, Executive Vice President, American College of Physicians – American Society of Internal Medicine (ACP – ASIM), Chair.
- Leslie M. Burger, MD, FACP, Major General (Ret), US Army, Director (Ret), VISN 20, Member.

- David W. Chandler, COL, MS, Director, Executive Agencies, Office of The Surgeon General, Member.
- John D. Durrant, PhD, Professor, Department of Communication Science & Disorders and Otolaryngology, Director of Audiology, University of Pittsburgh Medical Center, School of Health and Rehabilitation Sciences, Member.
- Cynthia G. Fowler, PhD, Professor, Department of Communicative Disorders, University of Wisconsin, Member.
- James F. Jerger, PhD, Distinguished Scholar-in-Residence, University of Texas at Dallas, Member.
- Douglas Ohlin, PhD, US Army Center for Health Promotion and Preventive Medicine, Member.
- Donald E. Morgan, PhD, President, Hearing Resource Group Inc., Member.
- Allen F. Ryan, PhD, Professor of Surgery/Otolaryngology and Neuroscience, Director of Research, University of California at San Diego, School of Medicine, Division of Otolaryngology, Department of Surgery, Member.
- Leonard P. Rybak, MD, PhD, Professor, Department of Surgery, Division of Otolaryngology, Southern Illinois University, School of Medicine, Member.

NCRAR Local Advisory Council

- Lesley M. Hallick, PhD, Provost and Vice President of Academic Affairs, Oregon Health & Sciences University, Chair.
- G. J. (Jerry) Schleining, Department Service Officer, American Legion, Member.
- Michael P. Davey, MD, PhD, Associate Chief of Staff, Research Service, Portland VAMC, Member.
- John W. Kendall, MD, Academic Affiliation Liaison, VISN 20, Professor, Department of Medicine and Dean Emeritus, Division of Endocrinology, Diabetes and Clinical Nutrition, Oregon Health & Science University, Member.
- Mark A. Richardson, MD, MScB, MBA, Dean, School of Medicine, Oregon Health & Science University, Member.
- James A. Tuchschmidt, MD, MM, Director, Portland VAMC, Member.

V. INFORMATION DISSEMINATION

The NCRAR serves as a national resource for hearing impaired veterans, their families, the community at large, and rehabilitation research and health care professionals. NCRAR rehabilitation researchers actively influence their fields by contributing to the integration of evidence-based research findings into clinical practice throughout the VA health care delivery system and the nation. In so doing, the NCRAR and its staff serve as VA ambassadors within their institutions and their professional organizations, effectively advancing the VA and the RR&D Service in the professional community and national consciousness. During 2006, the NCRAR effectively disseminated the following information:

Publications in the Journal of Rehabilitation Research and Development (JRR&D, n = 1)

Lewis MS, Lilly DJ, Hutter MM, Bourdette DN, Saunders J, Fausti SA. Some effects of multiple sclerosis on speech perception in noise: Preliminary findings. J Rehabil Res Dev. 43(1):91-98, 2006.

Publications in Press, Under Review, or in Preparation for the JRR&D (n = 5)

Ellingson RM, Helt WJ, Gordon JS, Fausti SA. Objective, directional, full frequency, binaural microphone evaluation of clinical headphone insertion loss. J Rehabil Res Dev. (In preparation).

Henry JA, Loovis C, Montero M, Kaelin C, Anselmi KA, Coombs R, Hensley J, James K. Randomized Clinical Trial: Group Counseling Based on Tinnitus Retraining Therapy. J Rehabil Res Dev. (In press).

Henry JA, Rheinsburg B, Owens KK, Ellingson RM. Tinnitus malingering. J Rehabil Res Dev. (In preparation).

Henry JA, Rheinsburg B, Ellingson RM. Computer-automated tinnitus assessment: noise-band matching, maskability and residual inhibition. J Rehabil Res Dev. (In preparation).

Lilly DJ, Hutter MM, Lewis MS, Levitt H, Kusumoto A, Fausti SA. Development of a sound-field system and materials for the measurement of speech intelligibility in multi-talker babble. J Rehabil Res Dev. (In preparation).

Publications in Other Scientifically Peer-Reviewed Journals and Books (n = 26)

Barkhuizen A, Lim L, Trune DR, Rosenbaum JT. Eye, Aural, and Oral Manifestations. *Dubois' Lupus Erythematosus*. 7th Edition. D. Wallace and B. Hahn (eds.). William & Wilkins, Baltimore, 2006.

Emmer MB, Silman S, Silverman CA, Levitt H. Temporal integration of the contralateral acoustic-reflex threshold and its age-related changes. J Acoust Soc Am. 120(3):1467-73, 2006.

Fausti SA, Helt WJ, Gordon JS, Reavis KM, Phillips DS, Konrad-Martin D. Audiologic monitoring for ototoxicity and patient management, In: Campbell KC, editor. Pharmacology and Ototoxicity for Audiologists, pp. 230-248. 2006.

Hargunani CA, DeGagne JM, Kempton JB, Trune DR. Inner ear uptake and distribution of dexamethasone injected into the middle ear. Otol & Neurotol. 27:564-9, 2006.

Henry JA, Rheinsburg B, Owens KK, Ellingson RM. New instrumentation for automated tinnitus psychoacoustic assessment. Acta Otolaryngol Suppl. 126:34-38, 2006.

Henry JA, Schechter MA, Zaugg TL, Griest S, Jastreboff PJ, Vernon JA, Kaelin C, Meikle MB, Stewart B. Outcomes of clinical trial: Tinnitus Masking vs. Tinnitus Retraining Therapy. J Am Acad Audiol. 17:104-132, 2006.

Henry JA, Schechter MA, Zaugg TL, Griest S, Jastreboff PJ, Vernon JA, Kaelin C, Meikle MB, Lyons KS, Stewart BJ. Clinical trial to compare Tinnitus Masking and Tinnitus Retraining Therapy. Acta Otolaryngol Suppl. 126:64-69, 2006.

Lauer AM, Dooling RJ, Leek MR, Lentz JJ. Phase effects in masking by harmonic complexes in birds. J Acoust Soc Am. 119(2):1251-9, 2006.

Levitt H. Digital hearing aids: a brief history. J Acoust Soc Am. 120(5)Part 2, 33157 (abstract), 2006.

Levitt H. Digital hearing aids: from wheelbarrows to ear inserts. J Acoust Soc Am. (web paper), 2006.

Lewis MS, Hutter M, Lilly DJ, Bourdette DN, Saunders J, Fausti SA. Frequency modulation (FM) technology as a method for improving speech perception in noise for patients with multiple sclerosis. J Am Acad Audiol. 17:605-616, 2006.

MacArthur CJ, Hefeneider SH, Kempton B, Parrish SK, McCoy S, Trune DR. Evaluation of the mouse model for acute otitis media. Hear Res. 219:12-23, 2006.

MacArthur CJ, Hefeneider SH, Kempton B, Trune DR. C3H/HeJ mouse model for spontaneous chronic otitis media. Laryngoscope. 116:1071-1079, 2006.

MacArthur CJ, Hefeneider SH, McCoy SL, Trune DR. Development of a mouse model for acute otitis media. Hear. Res. 219:12-13, 2006.

MacArthur CJ, Trune DR. Mouse Models of Otitis Media. Current Opinion in Otolaryngology Head & Neck Surgery, 14:341-346, 2006.

Reavis KM, Lilly DJ, Fausti SA. Extended High-Frequency Calibration. ASHA Special Interest Division 6, Hearing and Hearing Disorders: Research and Diagnostics. 10(1) 13-15, 2006.

Ren T, He W, Matthews S, Nuttall AL. Group delay of acoustic emissions in the ear. J Neurophysiol. (online 16899644), 2006.

Ren T, Nuttall AL. Cochlear compression wave: an implication of the Allen-Fahey experiment. J Acoust Soc Am. 119:1940-1942, 2006.

Ryan AF, Wittig J, Evans A, Dazert S, Mullen L. Environmental micro-patterning for the study of spiral ganglion neurite guidance. Audiol Neurootol. 11:134-43, 2006.

Ryan AF, Ebmeyer J, Furukawa M, Pak K, Melhus A, Wasserman SI, Chung WH. Mouse models of induced otitis media. Brain Res. 1091:3-8, 2006.

Saunders GH, Forsline A. The Performance-Perceptual Test (PPT) and its relationship to aided reported handicap and hearing aid satisfaction. Ear Hear. 2006;27(3):229-242.

Saunders GH, Forsline A. The Performance-Perceptual Test (PPT) and its application to hearing aid counseling. The Hear Rev. 2006;13(13), 18-25.

Trune DR, Kempton JB, Gross ND. Mineralocorticoid receptor mediates glucocorticoid treatment effects in the autoimmune mouse ear. Hear Res. 212:22-32, 2006.

Trune DR. Ion homeostasis and inner ear diseases. Pp. 21-32, In: Hamid, M.A., and A. Sismanis (eds.) Medical Otology and Neurotology. A Medical Guide to Auditory and Vestibular Disorders. Thieme, New York, 2006.

Vaughan N, James K, McDermott D, Griest SE, Fausti SA. A 5-year prospective study of diabetes and hearing loss in a veteran population. Otol Neurotol. 27(1):37-43, 2006.

Vaughan NE, Storzbach D, Furukawa I: Sequencing versus non-sequencing working memory in understanding of rapid speech by older listeners. J Am Acad of Audiol. 17:506-518, 2006.

Publications in Press, Under Review, or in Preparation for Other Scientific Peer-Reviewed Journals and Books (n = 36)

Best V, Gallun FJ, Carlile S, Shinn-Cunningham B. Binaural interference and auditory grouping. J Acous Soc Am. (In press).

Fausti SA, Helt WJ, Ellingson RM, Gordon JS, Wilmington DJ. Efficient ototoxicity early detection using a portable handheld device. J Am Acad Audiol. (In preparation).

Gallun FJ, Mason CR, Kidd G Jr. Task-dependent costs in processing two simultaneous auditory stimuli. Perception & Psychophysics. (In press).

Ghaheri B, Kempton JB, Pillers DM, Trune DR. Cochlear cytokine gene expression in murine acute otitis media. Laryngoscope. (In press).

Ghaheri B, Kempton JB, Pillers DM, Trune DR. Cochlear cytokine gene expression in murine chronic otitis media. Otolaryngol Head Neck Surg. (Under review).

Ghaheri B, Pillers DM, Pang J, Kempton, JB, Trune DR. Impact of chronic otitis media on inner ear cytokine mRNA expression. Laryngoscope. (In press).

Gleich O, Leek MR, Dooling RJ. The influence of neural synchrony on the compound action potential, masking, and the discrimination of harmonic complexes in several avian and mammalian species. In Hearing - From Basic Research to Applications, edited by Kollmeier B, Klump G et al., Springer-Verlag: Heidelberg. (In press).

Griest SE, Folmer RL, Martin WH. Effectiveness of Dangerous Decibels®, a school-based hearing loss prevention program. Am J Audiol. (Under review).

Henry JA, Trune DR, Robb MJA, Jastreboff PJ. Neural and learning principles of tinnitus retraining therapy. J Am Acad Audiol. (In press).

Henry JA, Trune DR , Robb MJA, Jastreboff PJ. Tinnitus Retraining Therapy: guidelines for administering treatment. J Am Acad Audiol. (In press).

Henry JA, Schechter MA, Zaugg TL, Dennis KC. Lesson 8: Tinnitus. In Veterans Health Initiative (online VA Audiology tutorial), (In press).

Henry JA, Zaugg TL, Owens KK, Kaelin C., Schechter MA, Stewart BJ. Tinnitus-Impact Screening Interview: Development and Clinical Application. Am J Audiol. (Under review).

Kim HH, Addison J, Trune DR, Peter-Richter C. Otoprotective effects of dexamethasone in the management of pneumococcal meningitis: an animal study. Triologic Thesis, Laryngoscope. (Under review).

Konrad-Martin D, Henry JA. Tinnitus and Ototoxicity, (In preparation).

Lauer AM, Molis MR, Leek, MR. Discrimination of temporal fine structure by normal-hearing and hearing-impaired listeners. J Acoust Soc Am. (Under review).

Levitt H. A historical perspective on digital hearing aids: how digital technology has changed modern hearing aids. Trends in Amplification. (In press).

Lew HL Guillory SB, Jerger J, Henry JA. Auditory dysfunction in traumatic brain injury and blast related injury. J Am Acad Audiol. (In preparation).

Lewis MS, Saunders G. Tips for improving your listening experience. American Speech-Language-Hearing Association brochure, (In press).

MacArthur CJ, Pillers DM, Pang J, DeGagne JM, Kempton JB, Trune DR. Gram-negative pathogen klebsiella oxytoca is associated with spontaneous chronic otitis media in toll-like receptor 4 deficient C3H/HeJ mice. Acta Otolaryngologica. (Under review).

Martin WH, Griest SE, Howarth L, Nuttall A. Translational research: a model for science outreach in conjunction with scientific conferences. Science. (Under review).

Martin WH, Sobel JL, Griest SE, Howarth L, Shi Y-B. Noise induced hearing loss in children: Preventing the silent epidemic. J Otology. (In press).

McCoy SL, MacArthur CJ, Trune DR, Hefeneider SH. A novel treatment strategy for inflammation associated with otitis media. Laryngoscope. (Under review).

Meikle MB, Stewart BJ, Griest SE, Martin WH, Henry JA, Abrams HB, McArdle R, Newman CW, Sandridge SA. Assessment of tinnitus: Measurement of treatment outcomes. In B

Langguth, G Hajak, T Kleinjung, A Cacace, A Møller. (Eds.) Progress in Brain Research (supplement), Tinnitus: Pathophysiology and Treatment, Elsevier. (In preparation).

Molis MR, Leek MR. Categorization of ambiguous vowel stimuli by hearing-impaired listeners. J Acoust Soc Am. (In preparation).

Omelchenko I, Shi XR, Wang, XJ, Li AG, Trune DR, Nuttall AL. Roles of iNOS activity in sound- and age-related cochlear pathology. Hear Res. (Under review).

Saunders GH. Considerations for selecting and fitting hearing aids for older adults. ASHA Perspectives Newsletter. (In press).

Saunders GH, Echt KV. Rehabilitation Strategies for Dual-Sensory Impairment. Trends in Amplif. (Under review).

Saunders GH, Forsline A, Jacobs P. Attitudes toward Loss of Hearing Questionnaire (ALHQ): A comparison of electronic and paper formats. J Am Acad Audiol. (In press).

Saunders GH, Lewis MS. Effect of age on sound localization in the horizontal plane. (In preparation).

Trune DR, Kempton B. Blocking the glucocorticoid receptor with RU-486 does not prevent glucocorticoid restoration of autoimmune mouse hearing loss. Otol & Neurotol. (Under review).

Trune DR, Kempton JB, Malmin B, Pang J, Pillers DM. Abnormalities in peripheral and central auditory physiology of *mdx*^{Cv3} mouse model provide a potential basis for cognitive defects found in Duchenne muscular dystrophy. Science, (In preparation).

Trune DR, Kempton B, Harrison AR, Wobig JL. Glucocorticoid impact on cochlear function and systemic side effects in autoimmune C3.MRL-*Fas*^{lpr} and normal C3H/HeJ mice. Hear Res. (In press).

Tsung A, McCoy SL, Klune Jr, Geller DA, Billiar TR, Hefeneider SH. A novel inhibitory peptide of toll-like receptor signaling limits lipopolysaccharide-induced production of inflammatory mediators and enhances survival in mice. SHOCK. (In press).

Tufts JB, Molis MR. Perception of roughness by listeners with sensorineural hearing loss. J Acoust Soc Am Express Letters. (In press).

Turbin M, English K. Biopsychosocial audiology: “patient centered” may not be what you think. J Am Acad Audiol. (In preparation).

Turbin M, Istvan JA. Hearing Loss: a primer of causes, clinical correlates, and therapeutic issues for psychologists. Professional Psychology. (In preparation).

Turbin M, Istvan JA, Storzbach D. The emerging epidemic of hearing loss: Issues and opportunities for psychologists. Professional Psychology: Practice and Research. (In preparation).

Yueh B, Collins MP, Souza P, Boyko E, Loovis C, Heagerty P, Liu CF, Fausti S, Hedrick S. Screening for Auditory Impairment—Which Hearing Assessment Test [SAI-WHAT]: RCT design and baseline characteristics. Cont Clin Trials. (In press).

Presentations at Scientific and Professional Conferences, Meetings, and Symposia (n = 42)

Ellingson RM, Helt WJ, Helt PV, Fausti SA. Instrumentation system upgrade supports mobile personalized healthcare delivery. Podium presentation provided at the 28th IEEE EMBS Annual International Conference, New York, NY, August-September 2006.

Ellingson RM, Oken B, Zajdel D, Flegal K, Kishiyama S, Thong T. 24-hour ambulatory research system supporting multiple physiologic sensors. Poster presented at the 28th IEEE EMBS Annual International Conference, New York, NY, August-September 2006.

Fausti SA, Hutter MM, Lilly DJ, Lewis MS, Fitzpatrick M, Bourdette DN. Auditory dysfunction in patients with multiple sclerosis. Invited lecture presented at the Oregon Academy of Audiology, Salem, OR. February 2006.

Forsline A, Saunders GH. The Perceptual Performance Test and hearing aid outcome. Research podium presentation at the Audiology NOW! Annual Convention of the American Academy of Audiology, Minneapolis, MN, April 2006.

Forsline A. Hearing aid satisfaction: A discussion. Invited lecture presented at a meeting of the Hearing Loss Association of America: Clackamas Chapter, Lake Oswego, OR, May 2006.

Gallun E. Central auditory processing disorders and polytrauma. Invited lecture presented at the Dartmouth Polytrauma Conference, Hanover, NH, December 2006.

Ghaheri B, Kempton JB, Pillers DM, Trune DR. Cochlear gene array analysis of murine acute and chronic otitis media. Poster presented at the Western Section Triologic Society Meeting, San Diego, CA, February 2006.

Ghaheri B, Kempton JB, Pillers DM, Trune DR. Cytokine gene expression in murine chronic otitis media. Poster presented at the American Academy of Otolaryngology Head & Neck Surgery Conference, Toronto, September 2006.

Gleich O, Leek M, Dooling R. The influence of neural synchrony on the compound action potential, masking, and the discrimination of harmonic complexes in several avian and mammalian species. Poster presented at the International Symposium on Hearing, Cloppenburg, Germany, August 2006.

Griest S. Tinnitus: the other consequence of noise. Invited lectures presented as Occupational Hearing Conservation Certification Course offerings, Hearing and Speech Institute, Portland, OR, 2006.

Hargunani CA, Kempton B, DeGagne JM, Trune DR. Inner ear pharmacokinetics of dexamethasone following intratympanic injection. Poster presented at the Association for Research in Otolaryngology, Baltimore, MD, February 2006.

Henry JA. Treatment options for tinnitus. Invited lecture presented at the Cleveland Clinic 6th Biennial Audiology Symposium, Innovations in Hearing, Cleveland, OH, August 2006.

Henry JA, Zaugg TL, Schechter MA. Clinical procedures for audiologic tinnitus management. Invited lecture presented at the Indiana Speech, Language, and Hearing Association Winter Conference, Indianapolis, IN, February 2006.

Henry JA, Zaugg TL, Schechter MA. Audiologic tinnitus management: what to do and how to do it. Learning lab presented at Audiology NOW! Annual Convention of the American Academy of Audiology, Minneapolis, MN, April 2006.

Henry JA, Zaugg TL, Schechter MA. Tinnitus evaluation and treatment. Invited one-day workshop presented at the Illinois Academy of Audiology 13th Annual Convention, Chicago, IL, January 2006.

Hutter M, Lewis MS, Lilly D, Fitzpatrick M, Bourdette D, Whitham R, Fausti SA. Central auditory function in people with multiple sclerosis. Poster presented at the Consortium of Multiple Sclerosis Centers Conference, Scottsdale, AZ, May 2006.

Jacobs PG, Erdogmus D, Wan EA, Leek M, Fausti SA. Development of an audio-visual dual-sensory assist device using mutual information optimization. Poster presented at the International Hearing Aid Research Conference (IHCON), Lake Tahoe, CA, August 2006.

Konrad-Martin D. Effects of stimulus level and hearing status on OAE latencies. Invited lecture presented at the University of Colorado at Boulder, Department of Speech, Language & Hearing Sciences, Boulder, CO, January 2006.

Lauer AM, Dooling RJ, Leek MR. Impaired frequency resolution in canaries with hereditary hearing loss. Poster presented at the Acoustical Society of America Annual Meeting, Providence, RI, June 2006.

Levitt H, Nilsson M, Bray V. Interaction of noise reduction and directionality in hearing aids. Paper presented at Audiology NOW! Annual Convention of the American Academy of Audiology, Minneapolis, MN, April 2006.

Levitt H. Computer assisted tracking. Paper presented at State of the Science Conference on Hearing Enhancement, Gallaudet University, Washington, DC, September 2006.

Lewis MS, Hutter MM, Musiek F, Lilly DJ, Bourdette DN, Fausti SA. Temporal resolution in patients with multiple sclerosis. Poster presented at AudiologyNOW! Annual Convention of the American Academy of Audiology, Minneapolis, MN, April 2006.

Lewis MS**,** Lilly DJ, Gordon J, Crandell C, Fausti SA. Speech perception in noise in the FM + EM listening condition. Poster presented at AudiologyNOW! Annual Convention of the American Academy of Audiology, Minneapolis, MN, April 2006.

Lewis MS. Applications of directional microphone and frequency modulation (FM) technology for the adult population. Invited lecture presented at the Oregon Academy of Audiology meeting, Salem, OR, February 2006.

Lewis MS. Incorporating verification and validation procedures into clinical practice. Invited lecture presented at the Oregon Hearing Society, Hood River, OR, June 2006.

Lilly DJ. Bad noise, good noise: hearing protection and the use of noise to evaluate hearing aids. Invited lecture presented at the Oregon Hearing Society, Hood River, OR, June 2006.

Lilly DJ. Bone conduction, the occlusion effect and transcranial CROS hearing aids. Invited lecture presented at the Annual Conference of the International Hearing Society, San Antonio, TX, October 2006.

Lilly DJ. Dizziness and balance: the other part of the ear. Invited lecture presented at the 34th Annual Tri-State Hearing Convention, Coeur d'Alene, ID, March 2006.

Lilly DJ. Noise, the human auditory system and hearing aids. Invited lecture presented at the Annual Conference of the International Hearing Society, San Antonio, TX, October 2006.

Lilly DJ, Hutter MM, Lewis MS, Fitzpatrick MP, Bourdette DN, Fausti SA. Auditory dysfunction in patients with multiple sclerosis. Poster presentation at the Bi-annual Congress of the International Society of Audiology, Innsbruck, Austria, September 2006.

Molis MR, Leek MR. Categorization of ambiguous vowel stimuli by hearing-impaired listeners. Poster presented at the American Auditory Society Annual Meeting, Scottsdale, AZ, March 2006.

Saunders GH. Considerations for rehabilitation of individuals with dual sensory impairment. Paper presented at the Academy of Rehabilitative Audiology Institute, Louisville, KY October 2006.

Saunders GH. Impact of dual-sensory loss on technology selection and fitting. Invited lecture presented at the State of the Science Workshop on Hearing Enhancement, Gallaudet University, Washington, DC, September 2006.

Saunders GH. Hearing loss and hearing aids. Invited lecture presented at the State of the Science Workshop on Sensory Impairments at Walter Reed Army Medical Center, Washington DC, April 2006.

Saunders GH, Forsline A. The Performance-Perceptual Test as a counseling tool. Poster presented at the International Hearing Aid Research Conference (IHCON), Lake Tahoe, CA, August 2006.

Trune DR, Kempton B, DeGagne JM, Hargunani CA. Steroid control of cochlear inflammatory factors in autoimmune inner ear disease. Poster presented at the Association for Research in Otolaryngology Meeting, Baltimore, MD, February 2006.

Trune DR, Kempton B, MacArthur CJ. Prednisolone improvement of cochlear function in mice with chronic otitis media. Poster presented at the Association for Research in Otolaryngology Meeting, Baltimore, MD, February 2006.

Trune DR, Kempton B, DeGagne JM, Hargunani CA. Steroid control of cochlear inflammatory factors in autoimmune inner ear disease. Invited lecture presented at the Northwest Auditory and Vestibular Research Meeting, Portland, OR, July 2006.

Trune DR, Kempton B, MacArthur CJ. Prednisolone improvement of cochlear function in mice with chronic otitis media. Invited lecture presented at the Northwest Auditory and Vestibular Research Meeting, Portland, OR, July 2006.

Tufts JB, Molis MR. Perception of roughness by people with normal hearing and sensorineural hearing loss. Poster presented at the 151st meeting of the Acoustical Society of America, Providence, RI, June 2006.

Turbin M. Counseling hard of hearing adults: issues, resources, skills. Invited lecture presented at the Rehabilitation Services Administration National Training Program, Rehabilitation Counseling for Deaf and Hard of Hearing Adults, Western Oregon University, Monmouth OR, July 2006.

Zaugg TL, Griest S, Schechter MA, Henry JA. MML changes after treatment with TRT and tinnitus masking. Audiology NOW! Annual Convention of the American Academy of Audiology, Minneapolis, MN, April 2006.

VI. PROFESSIONAL EDUCATION AND COMMUNITY OUTREACH

Sponsored Meeting

The NCRAR hosted the RR&D Center Directors' National Meeting entitled in Portland, OR on October 23rd – 24th, 2006. Lucille Beck, PhD, Chief Consultant for Medical Rehabilitation, and Director, Audiology & Speech Pathology Program, was the Keynote Speaker. In addition to brief updates from individual Centers of Excellence, special invited presentations were provided by Henry Lew, MD, PhD, Clinical Associate Professor, School of Medicine, Stanford University, and Director of Clinical Research, Physical Medicine & Rehabilitation Service, VA Palo Alto Health Care System; David Chandler, PhD, Colonel, United States Army, and Director, DoD Executive Agencies Directorate Headquarters, Department of the Army, Office of the Surgeon

General; and R. Keith Martin, PhD, Lieutenant Colonel, United States Army, Medical Service Corps Military Deputy to the Principal Assistant for Research & Technology Headquarters, U.S. Army Medical Research and Materiel Command.

Sponsored Clinical Research Seminars

Benjamin Hornsby, PhD, Research Assistant Professor, Vanderbilt University, Nashville. Tennessee. Factors affecting the benefit of amplified speech for persons with hearing loss. March 10, 2006.

Margaret Collins, PhD, Clinical Audiologist, VA Puget Sound Health Care System, Seattle, Washington. Subjective hearing complaints and sentence recognition performance for listeners with posttraumatic stress disorder. April 25, 2006.

John Coverstone, MS, FAAA, Consulting Audiologist, Sentient Health Solutions, Minneapolis, Minnesota. Clinical assessment of vestibular and balance disorders. May 18, 2006.

Robert Folmer, PhD, Associate Professor of Otolaryngology, Oregon Hearing Research Center, Oregon Health & Science University, Portland, Oregon. Auditory symptoms resulting from head or neck injuries. May 25, 2006.

Frederic Gallun, PhD, Research Assistant Professor, Department of Speech, Language and Hearing Sciences and Hearing Research Center, Boston University. Listening in complex environments: Thinking beyond the cochlea. June 16, 2006.

Harvey Abrams, PhD, Chief, Audiology & Speech Pathology Service, Bay Pines VA Health Care System, Bay Pines, Florida. Improved quality of life: Do audiologists really make a difference? August 8, 2006.

Christina Dodge, ANP, PMHNP, Nurse Practitioner, Portland VA Medical Center, Portland, Oregon. Post traumatic stress disorder (PTSD): The invisible epidemic. October 4, 2006.

Margaret Peak, PhD, Assistant Chief, Audiology & Speech Pathology Service, Biloxi VA Medical Center, Biloxi, Mississippi. The effects of Hurricane Katrina on the Biloxi VAMC Speech Pathology & Audiology Service. October 19, 2006.

Jonathan Kil, MD, President & CEO, Sound Pharmaceuticals, Seattle, Washington. Reduction of cisplatin ototoxicity and neurotoxicity, potential therapeutic strategies. October 31, 2006.

Sarah Melamed, PhD, University of Illinois, Urbana-Champaign, Illinois. Objective measures of tinnitus in humans: New findings. November 17, 2006.

Workshops

Trune DR. Immunologic responses of the inner ear. Invited workshop presented to the Department of Otolaryngology, Tripler Army Medical Center, Honolulu, HI, December 2006.

Trune DR. Cochlear ion homeostasis and related hearing disorders. Invited workshop presented to the Department of Otolaryngology, Tripler Army Medical Center, Honolulu, HI, December 2006.

Turbin M. Counseling Hard of Hearing Adults: Issues and Resources. Invited workshop presented at the Annual National Rehabilitation Counseling for Deaf and Hard of Hearing Adults Summer Program at Western Oregon University, Monmouth OR, July 2006.

Community Outreach

The NCRAR hosted a Ribbon Cutting grand opening dedication ceremony on June 27, 2006. The event was attended by the VA Chief Research & Development Officer, Acting Director of Rehabilitation Research and Development Service, Medical Director of VISN 20, Director of PVAMC, partners from other VA Centers of Excellence, OHSU School of Medicine faculty members and other academic affiliates, NCRAR National and Local Advisory board members, members of the DoD Hearing Conservation Workgroup, representatives of Oregon's Congressional Delegation, Officers of Veteran Service Organizations, members of community groups serving those with hearing loss, and veterans and staff of the PVAMC. Speakers at the Dedication Ceremony were Dr. James Tuchschmidt, PVAMC Director, Dr. Michael Davey, PVAMC Associate Chief of Research, Dr. Leslie Hallick, OHSU Provost and Vice President of Academic Affairs, Dr. Geoffrey McCarthy, VISN 20 Chief Medical Officer, Dr. Joel Kupersmith, VA Chief Research & Development Officer, Dr. Robert Ruff, Acting Director RR&D, and Dr. Allen Ryan, NCRAR National Advisory Board member.

After the formal ceremony, attendees toured the new NCRAR facility and were offered two podium presentations by Dr. Marjorie Leek, NCRAR Deputy Director of Research. Titles of these presentations were "Traumatic Brain Injury and the auditory system" and "A hearing loss prevention program for veterans and the military". The tour included five demonstrations and associated posters: Tinnitus research at the NCRAR, tinnitus education at the NCRAR, a hearing aid demonstration and discussion of expectations about hearing aids, a demonstration of the Time-Compressed Speech Test developed at the NCRAR, a demonstration of high frequency audiometric testing with a discussion on ototoxicity, and a demonstration of the anechoic chamber. The presentations and tour were available to VA employees for TEMPO credit.

March 2006

On March 14th, the NCRAR presented an exhibit at ***Solutions for Better Hearing: A Resource Fair,*** hosted by Hearing Loss Association of America, Clackamas County Chapter. Patient education materials and information describing research at NCRAR were discussed and distributed.

April 2006

NCRAR hosted an exhibit booth at the American Academy of Audiology National Convention on April 6th-8th, in Minneapolis, Minnesota. The booth had over 3,000 visitors. NCRAR authored publications and other materials from VA RR&D were disseminated.

The NCRAR hosted a site visit from its National Advisory Board on April 17-18, in Portland, Oregon. The goals of the meeting were to develop a 5-year plan, including future partnerships and collaborations, educational activities and scientific directions, and to give input on the grant resubmission.

David J. Lilly, PhD co-authored an article in the April 2006 issue of The ASHA Leader entitled, "Current and emerging tools for the assessment of middle-ear function," with M. Patrick Feeney, PhD and John J. Rosowski, PhD.

May 2006

NCRAR research audiologist Anna Forsline, MA presented a community lecture titled "Hearing Aid Satisfaction: A Discussion" for the Hearing Loss Association of America, Clackamas Chapter, Lake Oswego, Oregon.

June 2006

On June 20th, Dawn Konrad-Martin, PhD organized an ASHA "Web Event" on the topic of age-related speech understanding deficit: Impact on health care, home care, and long-term care of older adults. The goal was to provide a generalist audience with real-world application of research results and some potential tools that can be used to work with elderly patients.

August 2006

On August 8th, the NCRAR presented a tour and lecture on hearing conservation for 18 high school students as partial fulfillment of their school health class requirement. The lecture demonstrated the typical volumes at which many young people listen to music using insert earphones with iPODs and MP3 players and showed resultant damage to the hair cells of the cochlea. The tour included a demonstration of the anechoic chamber, a compressed speech demonstration, a hearing test and hearing aid demonstration.

On August 28th, the NCRAR presented an educational tour for a visiting delegation of 24 Chinese health care workers who were interested in learning what is done for hearing loss in the US. Their tour included a demonstration of a hearing evaluation, a hands-on demonstration of hearing aids, and a listening experience in the anechoic chamber.

September 2006

On September 12th, Carolyn Landsverk, MS, presented a talk titled "Improving your Listening Experience" for the Hearing Loss Association of America, Clackamas County chapter.

October 2006

On October 3, 2006, Drs. James Henry and Tara Zaugg presented Part 1: "Tinnitus Retraining Therapy" of an open lecture to veterans and the general public, VA Medical Center, Portland, OR, and Part 2: "Tinnitus Retraining Therapy" on October 24, 2006.

November 2006

On November 14th – 18th the NCRAR presented an exhibit poster at the national convention of the American Speech-Language-Hearing Association (ASHA) in Miami Beach, Florida. The convention had 9,500 participants. NCRAR publications, VA RR&D materials, NCRAR traineeship and employment opportunities, and information on the NCRAR 2007 Biennial International Conference, Hearing Therapies of the Future, were distributed.

Tinnitus Education/Support Group Meetings

The NCRAR and Portland VAMC Audiology Clinic work jointly to provide ongoing support/education group meetings for veterans with tinnitus. Six meetings were conducted during 2006, and were facilitated by Drs. James Henry, Martin Schechter and Tara Zaugg. The purpose is to provide information that would be most helpful to veterans in managing their own tinnitus.

Expositions and Conventions

NCRAR disseminated information on recent publications, upcoming conferences, and technology development to thousands of attendees at two large professional conventions, the American Academy of Audiology (AAA) Convention, April 5-8, 2006, in Minneapolis, MN, and the American Speech-Language and Hearing (ASHA) Convention, November 18-20, Miami Beach, FL. Attendance at the AAA 2006 Convention was reported at 7,065 and the ASHA Convention had in excess of 10,000 attendees.

NCRAR Website

The NCRAR completed the conversion of its non-VA website (www.ncrar.org) to a "va.gov" domain (www.ncrar.research.va.gov), which continues to serve as a valuable means of communication and dissemination of information for professionals and the community. The website features a quarterly newsletter, calendar of events, publications and presentations, staff bios, abstracts of funded research programs and projects, professional links, employment opportunities, and information on NCRAR sponsored conferences and seminars.

Dangerous Decibels Exhibit

The "Dangerous Decibels" exhibit at the Oregon Museum of Science and Industry (OMSI) opened June 4, 2002. This interactive display, designed to educate both children and adults, is a collaborative effort involving the OMSI, Oregon Health & Science University – Oregon Hearing Research Center, American Tinnitus Association, and the NCRAR. The goal of the exhibit is to increase public awareness of noise-induced hearing loss and and tinnitus, and teach strategies to protect against hazardous noise exposure. The exhibit will remain on display at the OMSI until 2010.

VII. RESEARCH COLLABORATIONS

The NCRAR continuously seeks to expand its network of mutually beneficial collaborative partnerships with researchers in other federal agencies, at VA and non-VA medical centers, academic institutions, private industry organizations and non-profit foundations, particularly with individuals having complementary rehabilitation research and development foci. We have developed and cultivated research collaborations with the following agencies, institutions and individuals:

- VA Centers of Excellence
  - Center for Aging Veterans with Vision Loss, Atlanta VAMC, Decatur, GA (Katharina Echt, PhD – Dual Sensory Impairment Rehabilitation; William De L'Aune, PhD – Research Design and Methodology, and Statistical Analyses)
  - Center of Excellence on Restoration of Function in Spinal Cord Injury and Multiple Sclerosis, West Haven, CT (Albert Lo, MD, PhD – Neural Plasticity; Stephen Waxman, MD – Neural Plasticity)
  - HSR&D Polytrauma and Blast-related Injuries QUERI, Palo Alto, CA (Henry Lew, MD, PhD – Blast Injury and Polytrauma Rehabilitation)
  - HSR&D Polytrauma and Blast-related Injuries QUERI, Minneapolis, MN (Nina Sayer, PhD, LP – Blast Injury and Polytrauma Rehabilitation)
  - HSR&D MS Center of Excellence – West, Seattle, WA/Portland, OR (Jodi Haselkorn, MD, MPH – Multiple Sclerosis and Auditory Function)
- VA Medical Centers
  - Bay Pines VA Healthcare System, FL (Harvey Abrams, PhD – Amplification, Aural Rehabilitation and Outcomes)
  - Biloxi VAMC, Biloxi, MS (Margaret Peak, PhD – Tinnitus Management)
  - James A. Haley VAMC, Tampa, FL (Paula Myers, PhD – Tinnitus Management and Patient Education Materials)
  - James H. Quillen VAMC, Mountain Home TN (Richard Wilson, PhD – Amplification and Aural Rehabilitation)

- Jesse Brown VAMC, Chicago, IL (Denis Moore, AuD – Tinnitus Management)
- Harry S. Truman Memorial Veterans' Hospital, Columbia, OH (Bonnie Wakefield, PhD, RN – Telemedicine)
- Loma Linda Healthcare System, Loma Linda, CA (Brenda Lonsbury-Martin, PhD – Otoacoutic Emissions and Ototoxicity Management; Glen Martin, PhD – Otoacoutic Emissions and Ototoxicity Management)
- Nashville VAMC, Nashville, TN (Gene Bratt, PhD – Ototoxicity Management)
- Portland VAMC, Portland, OR (SaraRuth Oliver, AuD – Amplification and Aural Rehabilitation; John McDermott, PhD – Amplification and Aural Rehabilitation; Martin Schechter, PhD – Tinnitus Management; David Hickam, MD, MPH – Health Services Research)
- San Diego VAMC, San Diego, CA (Allen Ryan, PhD – Biochemical Mechanisms of Ototoxicity and Hair Cell Regeneration)

- Oregon Health & Science University
  - Comprehensive Pain Center (Thomas Kern, PhD – Cognitive-Behavioral Therapy)
  - Department of Behavioral Neuroscience (Barry Oken, MD – Behavioral Neuroscience)
  - Department of Computer Science and Electrical Engineering (Alexander Kain, PhD – Speech Processing Engineering; John-Paul Hosom, PhD –Speech Recognition and Intelligibility; Deniz Erdogmus, PhD – Speech Perception and Signal Processing; Jan van Santen, PhD – Speech Recognition and Synthesis; Eric Wan, PhD – Speech Perception and Signal Processing)
  - Department of Nursing (Barbara Stewart, PhD – Research Design and Methodology, and Statistical Analyses)
  - Department of Public Health and Preventive Medicine (William Lambert, PhD – Environmental Epidemiology)
  - Diabetes Center (Andrew Ahmann, MD – Cognitive and Auditory Effects of Diabetes)
  - Oregon Cancer Institute (Grover Bagby, Jr., MD – Ototoxicity Management)
  - Oregon Hearing Research Center Tinnitus Clinic (William Martin, PhD – Noise and Hearing Loss Prevention and Tinnitus Management; Robert Folmer, PhD – Tinnitus Management; Mary Meikle, PhD – Tinnitus Management; Baker Yong-bing Shi, MD, PhD – Pathophysiology, Treatment and Management of Tinnitus)
- University and Hospital Collaborators
  - Australian Catholic University, North Sydney, Australia (Peter Wilson, PhD – Cognitive-Behavioral Therapy for Tinnitus Management)
  - Emory University, Atlanta, GA (Pawel Jastreboff, PhD, ScD, MBA – Tinnitus Retraining Therapy)
  - Indiana University, Bloomington, IN (Jennifer Lentz, PhD – Auditory Science)
  - Legacy Clinical Research and Technology Center, Legacy Health System, Portland, OR (W. Kenneth Ward, MD – Diabetes and Otoacoustic Emissions)
  - McMaster University, Ontario, Canada (Larry Roberts, PhD – Experimental Psychology and Tinnitus Management)

- Portland State University, Portland, OR (Judith Sobel, PhD – Health Behavior and Counseling in Community Interventions)
- University of Alabama, Tuscaloosa, AL (Beverly Thorn, PhD, ABPP – Psychological Aspects of Chronic Pain)
- University of California, Los Angeles' Norman Cousins Center for Psychoneuroimmunology, Los Angeles, CA (Michael Irwin, MD – Mechanisms of Neuroimmune Interactions)
- University of Connecticut, Storrs, CT (Frank Musiek, PhD – Central Auditory Processing; Jennifer Tufts, PhD – Speech Perception)
- University of Pittsburgh, PA (Kristina English, PhD – Aural Rehabilitation)
- University of Maryland, College Park, MD (Robert Dooling, PhD – Psychoacoustics; Amanda Lauer, MA – Psychoacoustics)
- University of Oregon, Eugene, OR (Terry Takahashi, PhD – Sound Localization and Central Auditory Processing)
- University of Regensburg, Regensburg, Germany (Otto Gleich, PhD – Auditory Physiology)
- University of South Florida, Tampa Bay, FL (Theresa Chisolm, PhD – Aural Rehabilitation)
- University of Washington, Seattle, WA (Pamela Souza, PhD – Hearing Aids and Speech Perception; Kelly Tremblay, PhD – Electrophysiology and Plasticity of the Central Auditory System)

- Institutes and Agencies
  - Army Audiology and Speech Center, Walter Reed Army Medical Center, Washington, DC (Brian Walden, PhD – Amplification and Aural Rehabilitation; Therese Walden, AuD – Amplification and Aural Rehabilitation; Kenneth Grant, PhD – Auditory-Visual Speech Perception; W. Van Summers, PhD – Psychoacoustics and Speech Perception)
  - Cleveland Clinic Foundation, Cleveland, OH (Craig Newman, PhD – Tinnitus Management; Sharon Sandridge, PhD – Electrophysiologic Assessment of Hearing)
  - Department of the Army, Office of the Surgeon General, Fallschurch, VA (LTC Kathy Gates, MS – Noise and Hearing Loss Prevention)
  - House Ear Institute, Los Angeles, CA (Sigfrid Soli, PhD – Hearing Loss Prevention and Hearing Conservation)
  - Madigan Army Hospital, Ft. Lewis Military Reservation, Tacoma, WA (CPT Dan Ohama – Noise and Hearing Loss Prevention)
  - Sensimetrics Corporation, Somerville, MA (Patrick Zurek, PhD – Speech Intelligibility, Digital Signal Processing and Communications Systems)
  - The Smith-Kettlewell Eye Research Institute, San Francisco, CA (John Brabyn, PhD – Dual Senory Impairment Rehabilitation)
  - U.S. Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, MD (Douglas Ohlin, PhD – Noise and Hearing Loss Prevention)
  - Womack Army Medical Center, Ft. Bragg, NC (LTC Vicki Tuten, AuD – Noise and Hearing Loss Prevention)

VIII. SERVICE TO VA AND PROFESSIONAL ORGANIZATIONS

The NCRAR encourages its staff to remain active within their respective professional organizations and to serve the VA and the community through participation in clinical presentations, community seminars, support groups, grand rounds and other medical practice forums. NCRAR rehabilitation researchers also serve on numerous VA editorial and scientific merit review boards, advisory committees and task forces, as well as a plethora of professional advisory and review committees, editorial review boards, special study sections, and task forces. The following are representative of how the NCRAR staff served the VA and professional organizations during 2006:

- Ad hoc Reviewer, *Aging Health* (J. Henry).
- Ad hoc Reviewer, *American Journal of Audiology* (MS. Lewis).
- Ad hoc Reviewer, *Annals of Otology, Rhinology & Laryngology* (J. Henry).
- Ad hoc Reviewer, Brain (S. Hefeneider).
- Ad hoc Reviewer, *Ear and Hearing* (J. Henry; D. Konrad-Martin).
- Ad hoc Reviewer, *Hearing Research* (D. Trune).
- Ad hoc Reviewer, IEEE Engineering in Medicine and Biology (G. Saunders; P. Jacobs).
- Ad hoc Reviewer, *International Journal of Audiology* (J. Henry; D. Konrad-Martin; MS. Lewis).
- Ad hoc Reviewer, *Journal of Rehabilitation Research and Development* (M. Turbin).
- Ad hoc Reviewer, *Journal of Speech Language and Hearing Research* (J. Henry; G. Saunders).
- Ad hoc Reviewer, *Journal of the Acoustical Society of America* (D. Konrad-Martin; M. Leek).
- Ad hoc Reviewer, *Journal of the American Academy of Audiology* (M. S. Lewis).
- Ad hoc Reviewer, *Journal of the Association for Research in Otolaryngology* (D. Trune).
- Ad hoc Reviewer, National Science Foundation (D. Konrad-Martin).
- Ad hoc Reviewer, VA RR&D Merit Review Board (D. Konrad-Martin).
- Associate Coordinator, Steering Committee for the ASHA Division 6 (D. Konrad-Martin).
- Assistant Editor, *Journal of the American Academy of Audiology* (G. Saunders).
- Associate Editor, *Journal of the American Academy of Audiology* (J. Henry).
- Chair, Principal Investigator Committee, NCRAR, Portland, OR (G. Saunders).
- Chair, Program Committee, NCRAR-sponsored biennial international conference 'Hearing Therapies for the Future' to be held in Portland Oregon, September 27-28, 2007 (D. Konrad-Martin); Chair, Conference (G. Saunders).
- Chair, Space Committee, NCRAR, Portland, OR (M. Leek).
- Chair, School of Medicine, Department of Neurology, OHSU (D. Bourdette).
- Chair and Member, Oticon Scientific Advisory Board Meeting (M. Leek).
- Chair and Member, Planning Committee, Audiology NOW! (MS. Lewis).

- Co-Director/Associate Director, U.S. Department of Veterans Affairs MS Center of Excellence-West (D. Bourdette).
- Deputy Director, Administration & Technical Support, NCRAR, Portland, OR (P. Helt)
- Deputy Director, Education, Training & Outreach, NCRAR, Portland, OR (G. Saunders)
- Deputy Director, Research, NCRAR, Portland, OR (M. Leek)
- Director, OHSU MS Center of Oregon (D. Bourdette).
- Editor, NCRAR Newsletter, NCRAR, Portland, OR (G. Saunders).
- Executive Council, Associate Member Delegate, National Hearing Conservation Association (S. Griest).
- Executive Council, Individual Member Delegate, National Hearing Conservation Association (S. Griest).
- Guest Editors, special issue of Seminars in Hearing (N. Vaughan; S. Fausti).
- Invited Reviewer, Health Services Research and Development Merit Review Board (G. Saunders).
- Invited Reviewer, Royal National Institute for the Deaf, Research Grants, London, UK (G. Saunders).
- Manager, Electron Microscopy Facility, Department of Otolaryngology, OHSU (D. Trune).
- Member, Advisory Committee, Ninth International Tinnitus Seminar, Goteborg, Sweden (J. Henry).
- Member, Advocacy and Legal Committee, American Tinnitus Association (J. Henry).
- Member, DoD Hearing Conservation Workgroup (S. Fausti).
- Member, Editorial Board, *Journal of the American Academy of Audiology* (MS. Lewis).
- Member, Editorial Board, *Journal of Rehabilitation Research and Development* (S. Fausti).
- Member, IRB Committee, Research and Development Service, Portland VAMC (J. Henry).
- Member, Medical Advisory Board of the National Multiple Sclerosis Society (D. Bourdette).
- Member, Medical Library Task Force, Portland VAMC, Portland, OR (M. Molis).
- Members, Executive Committee, NCRAR (S. Fausti; D. Smith; D. Phillips; G. Saunders; D. Konrad-Martin; M. Leek; P. Helt; D. McDermott; J. Gordon).
- Member, Membership Services Task Force, National Hearing Conservation Association (S. Griest).
- Member, Pre-convention Sub-committee for the 2006 American Academy of Audiology Convention (J. Henry).
- Member, Promotion & Tenure Committee, Department of Otolaryngology, OHSU (D. Trune).
- Members, Research & Development Committee, Portland VAM (J. Henry; G. Saunders; M. Leek).

- Member, Resident Research Committee, Department of Otolaryngology, OHSU (D. Trune).
- Member, Scientific Advisory Committee, American Tinnitus Association (J. Henry).
- Member, Scientific Advisory Council, United Cerebral Palsy Research Foundation (S. Fausti).
- Member, Training Grant Committee, Department of Otolaryngology, OHSU (D. Trune).
- Member, VA Audiology and Speech Pathology Program Office, National Professional Standards Board (S. Fausti).
- Member, VACO Field Research Advisory Committee, ORD (S. Fausti).
- Member, Working Group on Effective Interventions for Infants and Young Children with Hearing Loss, Office on Disabilities at the Department of Health and Human Services (S. Fausti).
- Members, Website Steering Committee, NCRAR (G. Saunders, D. Smith; P. Helt; C. Landsverk; A. Forsline; C. Kaelin; P. Jacobs).
- Organizer, Monthly Clinical Research Seminar Series, NCRAR, Portland, OR (G. Saunders)
- Organizer & Moderator, NCRAR/Portland VAMC Clinical Audiology Program Tinnitus Support Group (J. Henry).
- Panel Member, NIH Neuroepidemiology, Aging and Musculoskeletal Epidemiology Study Section (D. Trune).
- Panel Member, NIH ZRG1 HOP-C-02: Infectious Diseases, Reproductive Health, Asthma and Pulmonary Conditions/IRAP, SEP (D. Trune).
- Panel Member, NIH (NIDCD) R03 Grants (M. Leek).
- Panel Member, NIH (NIDCD) SEP: Translational Research Grants (D. Trune).
- President Elect, Academy of Rehabilitative Audiology (G. Saunders).

IX. TRANSLATIONAL RESEARCH ACHIEVEMENTS/IMPACTS

The NCRAR's multidisciplinary community of clinicians, rehabilitation researchers, and rehabilitation engineers focus their efforts on applied clinical research, auditory rehabilitation, and the development of useful strategies and technologies that are useful in the assessment and treatment of various facets of auditory function and dysfunction. We strive to combine evidence-based research findings with emerging technologies to optimize the effectiveness and efficiency of hearing health care delivery using computer-automation and tele-medicine principles. This focus has advanced the discovery of new knowledge about hearing impairments, which is directly influencing the field and contributing toward establishing standards of clinical practice while optimizing the aural rehabilitation of veterans with hearing disabilities. The following are representative of translational research achievements and impacts from the NCRAR:

AnalyzeOAE Software: NCRAR engineering staff continued development of a software application called AnalyzeOAE written in Matlab. The program performs signal processing and feature extraction including amplitude, latency, and signal-to-noise ratio (SNR) metrics for analyzing OAE waveforms collected using NCRAR's OAE measurement system. The software has been instrumental in a number of research projects at NCRAR (Nancy Vaughan, Dawn Konrad-Martin) and in acquiring pilot data for future studies (Eric Wan and Peter Jacobs).

Several new features were implemented in 2006. The first new feature is a Multi-File Processor. This feature enables investigators to process multiple files at once thereby saving time in data analysis. The next new feature is a new signal processing technique for calculating SNR of an OAE evoked using a *continuous* tone. Previous methods for detecting SNR were appropriate only for OAE's evoked using *pulsed* stimuli. Finally, a new method of calculating OAE signal metrics was developed. We determined that a significant improvement in OAE measurement repeatability and accuracy could be achieved by filtering individual OAE waveforms prior to extracting the metrics such as latency, amplitude, and SNR. After the metrics were extracted, we then averaged the metrics rather than averaging the entire raw waveforms as had been done previously.

AudioTest Software Suite: NCRAR engineering staff continued the development of the AudioTest Software Suite and added several critical new features. AudioTest Software Suite is a custom software application developed in Visual C#/C++, and designed to enable researchers to develop their own sound localization and questionnaire tests involving complex calibrated audio stimuli. The first new feature developed is an Automated Hearing Test tool. The program enables patients and clinicians to automatically test their hearing using off-the-shelf desktop PC equipment running the AudioTest software. At the conclusion of the hearing test, the patient receives an audiogram report. The second new feature is a Kiosk Tool. The Kiosk Tool enables investigators to run educational kiosk software and embed automated hearing test functionality within the kiosk. This program was developed in conjunction with Gabrielle Saunders and the kiosk program is expected to be utilized in the NCRAR's reception waiting area, and possibly in the atrium of the Portland VAMC. The AudioTest software has been installed in the anechoic chamber control room and is being used to run sound localization tests. The software will soon (April 2007) be deployed in Dawn Konrad-Martin's otoacoustic emissions (OAE) test booth to execute psychoacoustic testing and OAE data recording. We are currently working on an intellectual property rights agreement with the PVAMC so that AudioTest may be distributed to other research facilities.

Computer Automated Tinnitus Evaluation System (TES): NCRAR rehabilitation researchers and engineers have continued to enhance and refine the development of a computer-automated system for tinnitus quantification. The VA asserted ownership rights to this invention which has since been patented, and rights to the patent were obtained by a company that will be marketing the TES. An OHSU Invention and Intellectual Property Disclosure Form and a VA Report of Invention were submitted. In addition to Dr. Henry, project developers include Kimberly Owens, BS, Grayson Silaski, BSEE, Edward Porsov, MS, and David Gray, BSCE. Commercial opportunities include audiology clinics and hospitals worldwide.

Conference Proceedings Published in Special Issue of Seminars in Hearing: Proceedings from the NCRAR's 2005 biennial international conference entitled, "The Aging Auditory System: Considerations for Rehabilitation" were published in a special issue of *Seminars in Hearing* (2006;27:4:213-351). Drs. Nancy Vaughan and Stephen Fausti served as special guest editors in this issue devoted solely to publishing proceedings from the NCRAR conference.

Evidence-based Methods of Tinnitus Treatment: NCRAR rehabilitation researchers have recently completed three randomized clinical trials to evaluate methods of tinnitus treatment. VA audiologists have been trained to conduct the treatment methods being studied in these trials. As a result of receiving the training, these audiologists are able to directly apply their skills to veteran patients. Sites directly affected include the Puget Sound VA Healthcare System, Portland VAMC, Bay Pines VAMC, and San Diego VAMC. Dr. Henry has conducted numerous seminars

and workshops to train VA and non-VA audiologists in the clinical management of tinnitus. Each of these courses is designed to impart practical clinical knowledge to audiologists who can then apply the techniques in their own clinics.

Evidence-based Ototoxicity Early Identification and Monitoring Protocol: NCRAR rehabilitation researchers developed an evidence-based protocol for early identification and monitoring of ototoxic hearing change using proven behavioral methods. Our protocol has been shown to be time efficient (i.e., a time savings of two-thirds of what it takes using conventional methods), sensitive and reliable. This year we received a request to publish our protocol as a special chapter 'Audiologic Monitoring for Ototoxicity and Patient Management' in a book published by Thomson—Delmar Learning entitled, *Pharmacology and Ototoxicity for Audiologists*. This is the first book of its kind, and as such, it should enjoy wide readership among audiology AuD students.

Integrating Auditory and Visual Information to Improve Hearing Aids: NCRAR engineering staff continued development of an algorithm that can be used to improve the signal-to-noise ratio (SNR) of noisy audio data by comparing mutual information between auditory data and facial features within visual data. Preliminary results reveal that audio-visual processing can improve SNR over auditory processing alone. These results were presented at IHCON 2006 as part of a student scholarship award program. A grant was submitted in June 2006 (Marjorie Leek, PI, Peter Jacobs, Co-PI) to VA RR&D. The proposal was not funded and it is currently undergoing revisions for re-submission in June 2007. A preliminary patent submission will be forthcoming in 2007.

Multimedia program for a VA Hearing Loss Prevention Program (HLPP): Members of the NCRAR have developed a multimedia Hearing Loss Prevention Program aimed at veterans in collaboration with CraftMaster, a professional creative production company. The program is an instructional multimedia presentation that emphasizes prevention and behavior change as the key to minimizing further hearing loss among veterans during civilian life. The multimedia program consists of an introductory video explaining why prevention of hearing loss is important and which describes the content of the remainder of the program. The remainder of the educational part of the program consists of four sections which cover why prevention of hearing loss is important, how hearing can be protected, when protection is necessary and how the ear works. Each of these sections has a video module and an interactive module. The interactive modules permit the participant to tailor the program to his/her personal needs and lifestyle. Finally participants can test their own hearing using a self-administered screening hearing test via calibrated headphones. On completion of the program participants will each receive an informational print out and the results of their hearing test. The program will be evaluated to how effective it is at changing attitudes and behaviors of veterans towards exposure to loud environmental noise.

The presentation is currently being designed for use in a stand-alone kiosk but will be designed so that it can be adapted for use over the internet. A merit review proposal will be developed and submitted for funding with the goal of evaluating the efficacy of the intervention program.

Non-invasive Glucose Monitor Using Otoacoustic Emissions: NCRAR engineering staff continued development of a means to use amplitude and latency measures of ipsilaterally and contralaterally suppressed OAEs to predict blood glucose levels in diabetic patients. A preliminary patent was submitted March 2006. Additional diabetic patient studies were done in September 2006 – February 2007 verifying the functionality of the method, and an NIH R21 proposal was submitted in October 2006 (status pending). Preliminary results will be presented

at American Auditory Society March 2007, as a part of a mentored student scholarship award program. This work was done in collaboration with the computer science and electrical engineering department at the Oregon Health & Science University's Oregon Graduate Institute.

Ototoxicity Identification (OtoID) Device: NCRAR rehabilitation researchers have combined pure digital audio technology with a pocket PC platform to create a completely portable, battery operated device that enables individualized ototoxicity early identification with a high degree of efficiency, reliability, sensitivity, and specificity (VA asserted ownership rights January 2004). As part of an ongoing RR&D-funded rehabilitation engineering project, working prototype handheld and base units have been developed and are being tested by a Research Audiologist to acquire baseline hearing configurations. We continue the refinement of the OtoID system which is composed of a completely portable, battery operated instrument suitable for early identification of ototoxic hearing impairment. Comparison testing was performed in relation to readily available instrumentation, and the new OtoID device was found to have equivalent or superior reliability. Work is currently underway to implement ambient noise measurement screening capability which will enable testing in uncontrolled environments like hospital wards and patients' homes. Based upon feedback received from audiologist users, the software applications are also being refined to optimize the user-friendliness and streamlining of the ototoxicity monitoring protocol.

Performance-Perceptual Test (PPT): It is anticipated that the PPT will have clinical utility for testing actual versus perceived speech perception in noise and for counseling individuals that substantially either underestimate or overestimate their hearing ability. Data collected with the PPT suggests that underestimation of hearing ability is associated with more reported auditory handicap than expected and less satisfaction with hearing aids. Conversely, overestimation of hearing ability may be associated with 'denial' and a lack of motivation to acquire hearing aids.

Sound Localization Hardware / Software System: NCRAR engineering staff designed, built and installed a new speaker-mounting hardware / software system within the new anechoic chamber. The speaker mounting system involved a significant overhaul and upgrade to the previous sound localization test system including 4 new state-of-the-art Lynx 2B sound cards. These cards were incorporated into the AudioTest software system used to control the sound localization test program, and represent a significant improvement over the low-end sound cards (C-Media) used in the previous sound localization hardware system. The speaker mounting system consists of an aluminum circular truss system with mounting rods hung to enable mounting of speakers in a circular path around a subject being tested. The system was designed to be modular and enable the mounting of speakers at any height from ground level to7 feet high. All hardware in the chamber has been wrapped in acoustical foam to minimize reflections. The room has been connected to audio equipment in the control room with speaker wire that feeds in from the ceiling so that 24 speakers may simultaneously present audio at various calibrated levels. A public address (PA) monitoring system has been developed and installed that enables the subject to be in constant communication with the clinician during testing. All hardware has been evaluated and verified with the AudioTest Software Suite.

X. SUMMARY

The NCRAR is a leader in rehabilitative auditory research and development, having gained national recognition for its advancements in auditory research and rehabilitation, its contributions to professional education, and its mentoring and training of the next generation of scientists. The NCRAR is a comprehensive COE that includes the infrastructure, resources and multidisciplinary investigative team to serve as a national resource consistent with VA's Hearing Impairment Rehabilitation priority area. The research and development synergy created by this consortium of broad scope professionals, including both basic and clinical research components, brings diverse perspectives and cutting-edge solutions to common auditory problems. Continued support of this Center by the VA RR&D Service will allow the further development and expansion of the NCRAR's unique research and development contributions to the VA RR&D COE portfolio, and to the nation, by fostering the integration of research findings into clinical practice. The Center is ideally positioned to expand its role while maintaining its clear research focus on auditory rehabilitation. The work of the NCRAR and its collaborators to improve treatment options, rehabilitation strategies and hearing loss prevention is essential to optimize hearing health care and quality of life for hearing impaired veterans.